The Engineer

LONDON, FRIDAY, JUNE 6, 1941.

PUBLIC NOTICES

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L. A. P. WARNER,
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Town Hall,
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1940 No. 877
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The Engineer

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Automobile Research

AT a general meeting of the Institution of Automobile Engineers, held on Tuesday, May 27th, Mr. W. A. Tookey, M. Inst. C.E., M.I. Mech. E., and Dr. Edmund Giffen, D.Sc., Ph.D., presented papers dealing with research in the automobile industry. A keen discussion followed, in which emphasis was laid on the need for greatly enhanced support of co-operative research on behalf of the industry on the part of the manufacturers of motor vehicles, components and accessories. In this connection, Mr. Tookey pointed out that on the basis of the figures given in 1935 Census of Production for the motor and cycle trades, nearly £54,000,000 was the amount of added value to cost of material, fuel, and electricity, represented in the £132,000,000 quoted as the value of products. Thus the £4000 now subscribed for co-operative research by the vehicle manufacturers, engine makers, and motor cycle firms amounted only to three-fourths of a hundredth of 1 per cent. on the £54,000,000 of added value. Further points made in the discussion included references to the direct benefit accruing to the public from the results of co-operative research in the form of quieter and more efficient means of transport, and enhanced safety to the users of the road and the general public. Much had been done during the last ten years during which time the Research Committee had been under the ægis of the Institution, but much remained to be done. The committee could really be called the Automobile and Allied Industries Research Committee, because much of its work was of much wider application and valuable to all industries who used mechanical devices.

Water Schemes in the Highlands

AT the annual meeting of the Association for the Preservation of Rural Scotland, which was held last week, opposition was expressed to large water power schemes, such as that for Glen Affric, which is shortly to be the subject of a Bill in the House of Commons. In the opinion of the Master of Polwarth, who presided, the Glen Affric scheme should at any rate be postponed until the end of the war, when it should be considered in the light of a comprehensive planning scheme for the Highlands. Professor F. G. Baily said that the sort of power schemes which the Association had now been fighting for over twelve years meant the collection of the water power from a number of glens and its distribution from a central point to all parts of Scotland. His view was that each glen should be provided with its own water power, which, he held, would mean the development of each glen, for if one robbed any glen of its water power then it was hopeless to make that glen flourish. Scotland, he said, was very backward in its lack of small water power schemes. Professor Baily pointed out that the western seaboard of Scotland from Cape Wrath to the Firth of Clyde formed an area in which the small water power station offered great advantages. The whole of that particular coastal area was, he said, so deeply divided by sea and fresh water lochs that the construction of any long distribution line around the coast would be both difficult and expensive. In his opinion a number of separate small power supply stations offered practically the only possible method.

Merchant Shipping Losses

PRESIDENT ROOSEVELT recently said that the present rate of the German sinking of merchant ships was more than three times as high as the capacity of British shipyards to replace them, and that the present rate of sinkings was more than twice the combined output of British and American shipyards to-day. These impressive figures have caused considerable discussion. Reference to the Admiralty returns of shipping lost during the present year shows that for the first four months of the year the average rate of loss of British and Allied shipping was over 400,000 tons a month, amounting to about 5,000,000 tons in a year, should the rate of sinking be maintained. It must be pointed out, however, that the April losses included some Greek shipping lost in the Mediterranean, while figures for the present month, when available, may also include some such losses. Up to the present no exact figures of the British output of merchant ships have been published, but we may recall in that connection the statement of Sir Arthur Salter, made in January last, that although the rate of construction of merchant ships in this country was increasing, it had not yet passed the peak figure for the last war, when in 1918 1,348,000 gross tons were produced. Such a figure bears out the President's contention that the present rate of sinking is more than three times the rate of construction in British shipyards. As regards American shipyards, it was recently stated by Admiral Land, the Chairman of the United States Marine Commission, that when the present American shipbuilding programme gets into its full stride, the total output will probably be from 3,500,000 to 4,000,000 tons deadweight carrying capacity per year. If we take a ratio of 2 gross tons to 3 deadweight tons, then the lower figure would be about 2,300,000 gross tons, which, together with a larger British output of, say, 1,500,000 gross tons, would make a total of 3,800,000 gross tons for the combined output. Such a figure still falls below the present rate of German sinkings. Efforts are being made to increase both the British and the American outputs, and it is announced by the United States Maritime Commission that an arrangement has been made which will enable American vessels to handle all British shipping services from Canada and the United States to Australia and New Zealand, thereby releasing ships for a more direct part in our war effort.

The Contractors' Plant Association

AT a meeting of the principal hirers of contractors' plant, which was held at the Holborn Restaurant on Thursday, May 29th, those present unanimously resolved to adopt the constitution for the Contractors' Plant Association, which was submitted to the meeting. An interim committee was appointed, and it was charged with the duty of preparing regulations and by-laws governing membership, and of devising ways and means of giving effect to the objects of the Association. It was agreed that notice of the formation of the Association be sent to the Press, and that Derbyshire and Co., chartered accountants, of Africa House, Kingsway, London, W.C.2, should be appointed to act as temporary secretaries to the committee. Any inquiries concerning the Association and applications for membership from those qualified to join it should be sent to the secretaries at the address given above. Matters of urgent importance to the plant hirers' industry as a whole will, if brought to the secretaries' notice, be submitted to the interim committee, and it is hoped by such means that some degree of uniformity of action may be established in the mutual interests of all concerned in the welfare of the industry. Steps are to be taken at an early date to call a general meeting or district meetings of hirers, at which further information will be made available.

The Late Lieut.-Colonel H. H. Mauldin

RAILWAY engineers will learn with deep regret of the death of Lieut.-Colonel H. H. Mauldin, the divisional general manager of the London and North-Eastern Railway (Southern Area), which took place on Saturday last, May 31st, at Old Knebworth. Colonel Mauldin, who was fifty-nine years of age, started his railway career in the humble capacity of junior clerk at Fakenham in 1889. He was promoted several times and became a superintendent of the former Great Eastern Railway. After the outbreak of the last war he enlisted in the Royal Engineers in 1915 and reached the rank of Lieut.-Colonel in the office of Assistant Director of Railway Engineers (Stores Directorate) after the Armistice. When in January, 1923, the grouping of railways took place and the L.N.E.R. was formed, he was appointed chief assistant superintendent for the Southern Area, and at a later date, when that section was divided into eastern and western sections, he became superintendent of the eastern section. In 1939 he was promoted to the position of divisional general manager of the Southern Area of the London and North-Eastern Railway, a position which he filled with distinction until he died. In 1934 he was honoured by the King of Denmark, who conferred upon him the Order of the Knighthood of the Dannebrog, and he was also an officer of the Order of St. John of Jerusalem.

The Association of Scientific Workers

WE have just received a report of the annual Council meeting of the Association of Scientific Workers, which was held in Birmingham on May 24th and 25th. Eighty delegates were present, representing scientists and engineers in industrial and Government posts, as well as university staff and students. It was the first meeting of Council to be held since the registration of the Association as a trade union, and it was therefore natural that the reports which were presented, and the ensuing discussion, should be chiefly concerned with the planning of an industrial policy for the Association which would offer a solution, through trade union activity, to the immediate problems of scientific and technical staff. Discussion centred mainly around a report by the Industrial Sub-Committee of the Association, which analysed the present conditions of scientific and engineering staff. The report showed that even under peacetime conditions there was a considerable difference between salaries paid to people having the same qualifications but employed by different firms. In the engineering industry, for example, the general salary level was notably less than in certain chemical firms. A survey amongst members of the Association had shown that there was a marked tendency in industry for no increments to be given, while in Government establishments wartime posts carried a fixed salary. It was pointed out in the discussion that cancellation of increments was particularly unfair to the younger scientists, whose salaries were frozen at the low starting figure, with no prospects of advancement as they became more experienced. Since the University Joint Recruiting Boards restricted the type of firm in which a post could be sought on graduation, the individual now had in effect to accept a post, irrespective of the salary offered. Attention was directed in the discussion to the injustices caused by failure to grant payment for overtime to many scientists and engineers. It was said to be a common experience, particularly in large works, for hours of work and holidays to be altered suddenly by managerial edict, without any consultation with unorganised sections of the staff. The conclusion drawn by the A.S.W. Industrial Sub-Committee and endorsed by the Council was that collective action through the Association was now proved to be the only effective method by which engineers and scientists could safeguard their conditions, and bring them into correct relationship with organised sections of industry. The Council unanimously adopted a resolution in favour of close co-operation between the Association of Scientific Workers and other trade unions.

Colliery Explosion at Whitehaven

IT is with regret that we have to record an explosion in the William Colliery at Whitehaven, Cumberland, which took place in an underground seam on Tuesday, June 3rd. According to the news so far received, deaths are reported of nine men and a further three are reported missing. Thirteen men are in hospital suffering from injuries and burns. The explosion took place at the Junction, which is about 2½ miles from the shaft. Some of the injured were the youths engaged in assembling tubs at the Junction. The workings of the pit extend several miles under the sea, and beyond the point where the explosion took place several men, from sixty to seventy in number, were working. They were able to get back to the shaft by using a return airway and a drift which had only been recently completed. The William Colliery was sunk in 1812 and is one of the oldest undersea mines in Great Britain. Near to it is the Haig Colliery. Some time ago both pits ceased to mine coal and were closed down but they were restarted before the war by means of a grant from the Nuffield Trust.

Naval Losses Around Crete

AN official Admiralty *communiqué*, issued last week, refers to the naval losses around the Island of Crete. It states that our naval operations prevented any enemy landing in force on the island up to the time of evacuation, and also inflicted heavy losses upon laden enemy transports which endeavoured to reach the island. Operations of this type in confined waters and without fighter protection against the very large air forces employed by the enemy cannot, the communication states, be carried out without loss, and the Board of Admiralty regrets to announce the loss of the following ships :—Three cruisers, H.M.S. "Gloucester," H.M.S. "Fiji," and H.M.S. "York," and four destroyers, H.M.S. "Juno," H.M.S. "Greyhound," H.M.S. "Kelly," and H.M.S. "Kashmir." The "Gloucester" was a cruiser of the "Southampton" class and was laid down at Devonport Dockyard in September, 1936. Her machinery was supplied by Scott's Shipbuilding and Engineering Company, Ltd., of Greenock, and she was completed in January, 1939. The "Fiji," the name ship of a class of thirteen ships, was built and engined at Clydebank by John Brown and Co., Ltd. She was begun at the end of March, 1938, and was completed in 1940. The "York" was an interesting cruiser; she was designed by Sir William Berry and marked the first attempt on the part of one of the Treaty Powers to break away from the standard 10,000-ton type of cruiser. She was built and engined at Palmer's, and was laid down at Jarrow in May, 1927, and completed in June, 1930. Her displacement was 8250 tons, with a length overall of 575ft., a beam of 57ft., and a mean draught of 17ft. Her armament comprised six 8in. guns and eight 4in. anti-aircraft guns, with smaller guns. Six 21in. torpedo tubes were carried in triple mountings. One aircraft with a launching catapult was carried. She was undergoing repair in Suda Bay. Of the destroyers, the "Kelly" was a leader of the "Javelin" class, and was built and engined by R. and W. Hawthorn, Leslie and Co., Ltd. She was begun in August, 1937, and was completed a year later. Her sister ship, the "Juno," was built and engined by the Fairfield Shipbuilding and Engineering Company, Ltd., at Govan, and was begun in October, 1937, and completed in August, 1939. The "Greyhound" was built and engined by Vickers-Armstrongs, Ltd., at Barrow-in-Furness, and was begun in September, 1934, and completed in January, 1936. The "Kashmir" (ex "Javelin") was built and engined by John I. Thornycroft and Co., Ltd., at Woolston, Southampton. She was begun in October, 1937, and was completed in 1939.

Further Canadian Locomotive Experiences

By EDWARD H. LIVESAY

No. V

(*Continued from page 348, May 30th*)

CALGARY TO VANCOUVER

TO me the depôt at Calgary is different from all other depôts. It is both an entrance and an exit. Whether one is going east or west is immaterial, as the same thing applies. It is seemingly a dividing line between two contrasting worlds. On the one hand, the sea of mountains, rivers, and canyons that are British Columbia, and on the other the vast, treeless plain that constitutes the Prairie Provinces. If I am going east on the transcontinental trip, I heave a sigh of resignation on reaching Calgary; the thrills are over, only monotony lies ahead. The prairie always makes me think of the bluejacket's description of Scapa Flow. This—suitably censored and translated from the vernacular—becomes, "Millions and millions of gallons of water surrounded by miles and miles of nothing at all." Substitute acres of land for gallons of water and the rest of the formula can remain unaltered; that is, what you enter upon going east from Calgary. But going west—ah, that's quite another kettle of fish! Starting, I feel increasing animation; not exactly excitement, but something of that order—animation anyway. "In a few hours I shall be in the Rockies. For a day and a night glorious scenery, fascinating locomotive work, and innumerable things worthy of attention. There will never be a dull moment all the way through B.C., and at Journey's End, Vancouver and the Pacific—and, best of all, Victoria, the haven where I would be." On this particular occasion I was even more keyed up than usual, because I was looking forward to making the trip on an engine of a particularly interesting class, one of the new Canadian Pacific "5920 T-1-b 2-10-4s," the latest development of the "5900" class, on which I had come through a couple of years before, as described in THE ENGINEER of March 10th, 1939. Fig. 16 illustrates "No. 5924," on which I travelled. These engines were designed by Mr. H. B. Bowen, the Chief of Motive Power, and were built by the Montreal Locomotive Works in 1939. Though very similar to the "5900s" certain alterations have been made, based on experience with the prototypes. The driving wheels are 5ft. 3in. in diameter, but the steam pressure has been raised from 275 lb. to 285 lb., and the cylinders reduced ½in. to 25in., the stroke remaining 32in., the tractive effort being unaffected. They are booster equipped. The boiler has a maximum diameter of 8ft. 0½in., and the length between tube plates is 20ft. 11in. The heating surface totals 7086 square feet, the tubes, arch tubes, and fire-box supplying 5063 square feet, and the superheater 2032 square feet. The grate area is 93·5 square feet. For adhesion 138 tons are available, and the total weight of the engine is 200 tons; with tender, 330 tons. The latter carries 12,000 gallons of water and 4100 gallons of oil fuel. The tractive effort, with the booster, is 89,400 lb. The rigid wheel base is 22ft., the total engine base being 46ft.

These engines are several tons lighter than their forerunners, owing to the use of alloys and weight reduction wherever possible. Laird cross-heads are fitted instead of the heavier alligator pattern found on the "5900s." The oil fuel burner has been placed at the back of the fire-box, instead of at the front, better results having been found with it in this position. Their appearance has been greatly enhanced by the cleaning up of external details, and the adoption of semi-streamlining, which brings them into line with other modern types of Canadian Pacific locomotives. It may be mentioned that oil fuel is used in B.C. partly to reduce the risk of forest fires. It certainly makes things far more pleasant in the cab, as there is no dirt or smell, and incidentally the fireman can be of more service as a look-out, not being so continuously engaged with his fire. They are most impressive engines. For what it may be worth, I have never come in contact with any locomotives that attract me more!

"No. 5924" was at the head of "The Dominion" when I joined her in the depôt at Calgary this brilliant June morning, and on entering the cab I was glad to find Engineer McAnany in charge. I had ridden with him on "No. 5904" during my previous trip through the mountains. Fireman Olson was his left-hand man. Mr. Dickie, one of the Calgary locomotive staff, also came with me to Field to give any assistance in his power, greatly to the benefit of this account. After taking some photographs (Fig. 16 being a sample) the cab next claimed my attention, and Fig. 17 reproduces what I saw. I was struck by its neatness; it was quite at the top of the list in this respect. The engineer's controls on this class are very much the same as on the "2800s," previously described. It is on the fireman's side that differences are to be seen, due to oil fuel. His gauges are the usual—(A) steam, (B) booster, (C) feed-water heater, but below them will be seen a manifold (D) with five valves (1) fuel atomiser, (2) pump frost valve, (3) booster heater, (4) oil heater in winter, (5) blow-back oil line. The two horizontal handles H H below the manifold regulate the fuel and air supply (Fig. 5). The fire door is air-tight, clamped, except for the peep-hole, through which sand is fed to scour the tubes. When this is done the dampers are shut, thus inducing a fierce draught through the said hole, carrying the sand with it. Fig. 18 shows the arrangement of the burner, oil feed, and controls.

"The Dominion" got under way at 8.30 a.m., the train consisting of fifteen cars, say, 1275 tons—all my train weights are approximate, as the cars vary, and nobody ever seems to know just what the load is; "so many cars" is the nearest I can get when I ask. With the booster's help, the start gave no difficulty, and we were soon on the rising gradient out of Calgary. At 25 m.p.h. the throttle was half open and the cut-off 25 per cent. Pressure was a little down, to 250 lb. Sand was fed through the fire-box to scour the flues, and remove the layer of greasy deposit that forms with oil fuel, and is more tenacious than the soot from coal. There had been no slipping at the start or on the succeeding gradient while accelerating. With the booster cut in, the adhesion weight totals over 160 tons, which explains why no sand had been used when getting away; the rails were dry.

The riding of "No. 5924" was very good, and curves were taken well, in spite of the long rigid and total wheel base. I do not know if there is any side play allowed to the first coupled axle; I have no record of it. The leading truck is a Bissell, as is invariably the case in American practice, and the same arrangement is applied to the rear four-wheel truck—a forward-reaching yoke anchored to a cross stretcher. The L.M.S. "Coronations" illustrate the method in England. There was a slight box-pound on the left side; nothing very important. I have noticed this before on two-cylinder engines. It is probably the result of "left-hand crank leading" motion arrangement.

By this time we were well "away from the stinks and the sounds of town"—apologies to Calgary; poetic licence. I felt I was in for a fascinating trip, in perfect weather, and on an equally perfect locomotive—or *nearly* perfect, because I remember saying once that there is no such thing as a perfect locomotive, and there isn't. The scenery added to my enjoyment. We were following the Bow River, twisting and turning with it, rising higher and higher as the line got into the foothills, running through rolling country, sparsely tree covered, as the Rockies were neared. They were now in full view ahead, a craggy blue-grey mass of peaks, snow-capped. Stories, boyhood favourites, came back as grazing herds of cattle were passed, a cowboy—an Indian—reining up his horse, stoically watching "The Dominion" invade his Reserve. Down a little dip near Bearspaw, the speed rose to 55 m.p.h. This 2–10–4 was evidently capable of quite fast travelling. I was very pleased with the way it took the incessant curvature, so much better than one would anticipate with an engine wheel base of 46ft. I was reminded of another long wheel based engine I had ridden over a much-curving track—the L.N.E.R. 2–8–2 "Mons Meg," on the Edinburgh and Dundee line (THE ENGINEER, October 6th, 1939), and its equally good behaviour, which I had not been confident of, as the first time I had seen an engine of that class it had been off the metals at King's Cross. A depressing sight, yet its action over the Dundee line was admirable, and here was another engine, still lengthier, taking even worse curvature equally well. I do not know if any of the coupled flanges are thinned on this class or if the track gauge is spread a little on curves—I suppose it must be, or such a mastodon as "No. 5924" could not take them so unconcernedly.

The first stop was at Cochrane, for water, time 9.11 a.m., 41 min. for the 23 miles from Calgary. The track became more and more serpentine. Quoting my notes verbatim: "Curvature incessant—this division no place for nerves—or get back to train—look ahead and see S bends coming,

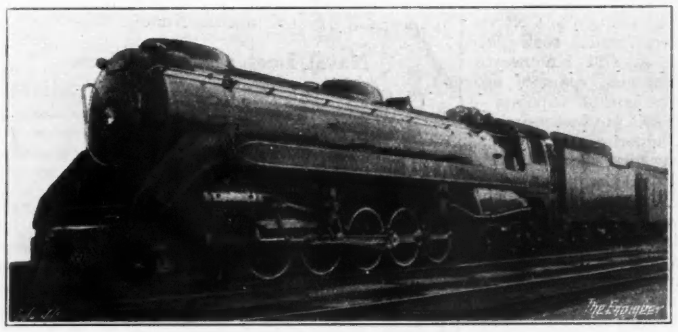

FIG. 16—C.P.R. 2-10-4 LOCOMOTIVE "5920" CLASS

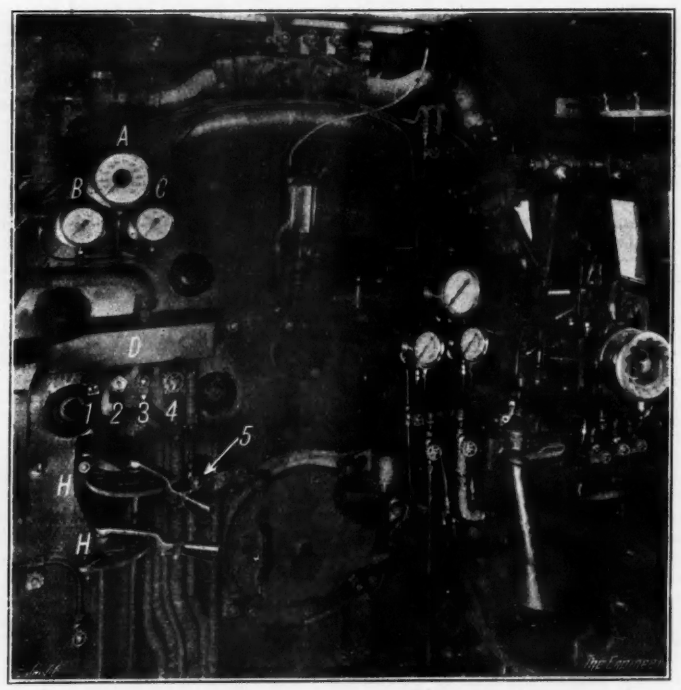

FIG. 17—CAB OF "5920" CLASS

think of 2–10–4 hitting them at 50—feel engine heel over right and left—but outer rail well elevated." You do not notice these things in the train, but you do from the cab.

There is fellowship among railwaymen. Sectionmen (platelayers) always wave to the cab people, and it is rank bad manners to ignore the salute. I paid toll for this once, on "The International Limited." In the absence of the fireman, "persecuting his vocation" away from his seat *pro tem.*, I took the salute, and returned it, knocking my pet pipe out of my mouth. The sectionmen got both, it and the greeting, as the engineer said he was sorry, but could not stop." "You can get another at Woolworth's for 25 cents." This custom reminds me of the early days of motoring—beginning with the writer in 1898—when one never passed another motorist without a friendly wave—on the principle, "We, who are liable to die at any moment, salute thee," probably.

At Morley one gets a magnificent view of the Rockies. We were running right into them at last—the surroundings became every moment more wild, woolly and western. But to get back to the engine; the revolving and reciprocating parts are naturally heavy on big engines such as this, and it was brought home by a notice in front of the engineer: "Do not close the throttle until speed has been reduced to less than 40 m.p.h." Yet the balance was so good that the motion was quite unobtrusive and there was little nosing, the result, I suppose, of the long wheel base.

At Kananaskis we were actually in the mountains, and a stop was made to put off supplies for an internment camp—the war had to intrude even in this primal wilderness. Then Exshaw, followed by passage of "The Gap," a gorge only a few yards wide, widening out again at Canmore. "The Dominion" was nearing Banff, climbing a 1 in 50 gradient, and "No. 5924" was shattering the silence of the mountains on full throttle and 30 per cent. cut-off. A stop at Lake Louise, the crystal water reflecting the towering mountains with such mirror-like perfection that a photograph can be held either way up, giving the same picture. Near Stephen the gradient became yet steeper, about 1 in 48, and again full throttle was called for, this time with a cut-off of 40 per cent. over the crest; the Ashcroft exhaust pressure gauge showed 12–13 lb., and the steam chest 285 lb., equal to the boiler pressure. There was evidently nothing the matter with "No. 5924's" front end. The booster was, of course, out of action at this speed. Shortly after Stephen, the summit, "The Great Divide," 5337ft. was reached, and the climb was over. Time 12.40 p.m. The 123 miles from Calgary, with eight stops, over heavy gradients that had lifted the train 1899ft., had been covered in 250 minutes. The average speed had therefore been 29·5 m.p.h., which, with a 1275-ton load, must be admitted to be good.

We were now closing the Spiral tunnels, built in 1909 to reduce the long and dangerous "Big Hill," on which the gradient had been 1 in 25. The track had to be lengthened down Kicking Horse Pass, but the valley is narrow and it could only be done by turning in under the mountains. Going west, it enters the first tunnel, 3255ft. long, beneath Cathedral Mountain, making a complete circle and coming out 54ft. lower down, there continuing some distance along the valley and crossing the Kicking Horse River. It then enters another tunnel, 2922ft. long, under Mount Ogden, again to make a circle and emerge 50ft. lower, finally carrying on to Field. It is really far from being as simple as this, as there are many minor curves—and not so very minor, at that—the whole lay-out for several miles representing a railwayman's nightmare, though it is a great improvement on the old location (Fig. 19).

FIG. 19—KICKING HORSE PASS AND SPIRAL TUNNELS NEAR FIELD

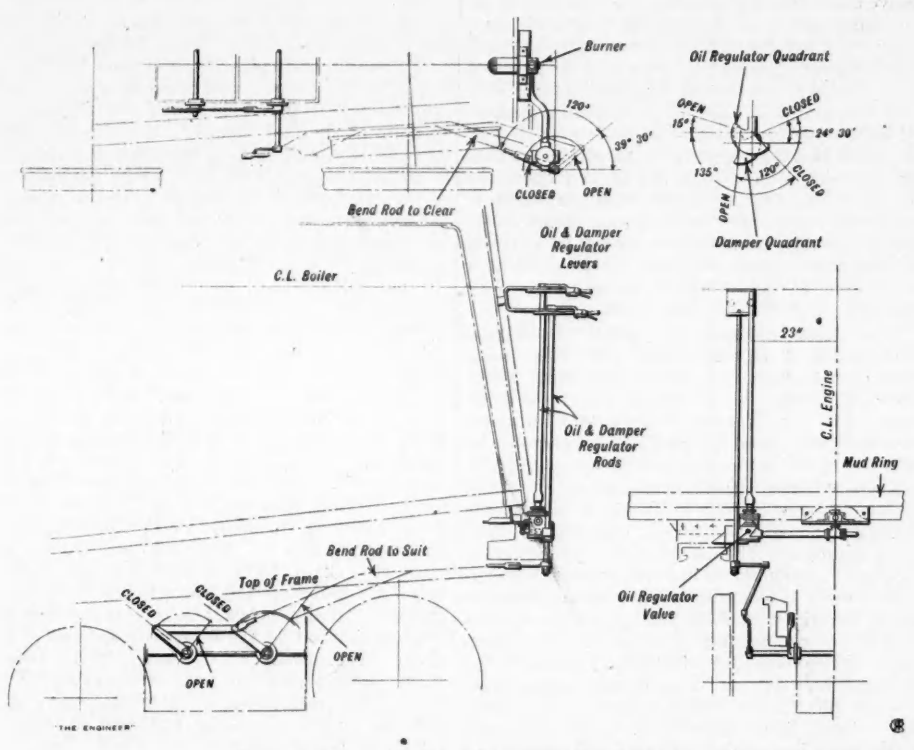

FIG. 18—FUEL AND AIR CONTROL CONNECTIONS

I looked forward to the passage of these tunnels with equanimity, as we should be going down, drifting, and the heat would be very much reduced. I had vivid recollections of going through them in the reverse direction on the second of two big engines, both on full throttle and valve travel, moving at only about 10 m.p.h. It is little exaggeration to say I endured the tortures of the damned, all the harder to bear because I could not help thinking they were grossly in excess of my deserts. What had I done, that I should suffer thus? A thunderous inferno of suffocating, sulphurous blackness—such were the Spirals. But on this occasion things were different. Running dead slow, we entered the upper tunnel, descending gingerly at 6–8 m.p.h., with throttle shut and brakes hard on, the headlamp shining on the wet concrete walls, to a musical accompaniment of tolling bell and flanges grinding round the continuous curve. Out into the sunshine again, a few minutes' running took the train across the Kicking Horse River into the second spiral. In this, a slight brake control defect slowed the train too much, and the throttle was opened for a hundred yards or so. At once the heat and sulphur fumes swirled into the cab, and memories of my former martyrdom revived. These tunnels are not ventilated, and I suppose that when they were built Schwitzer, the engineer, never realised how big engines would become (or perhaps the money ran out before a ventilating plant could be put in), but anyway, a locomotive such as "No. 5924" nearly fills them, and as the products of combustion have to go somewhere, they cannot be blamed for getting into my lungs. However, my sufferings were soon over, and I found myself out in the open, taking gulps of the delicious pure mountain air to clear the sulphur away. The scenery is superb here; one looks down into the great valley from high up the mountain side towards Field, in the midst of a sea of snow-clad peaks, the track twisting and turning, in full view for several miles. The engine was handled very carefully all along this stretch, never doing more than 25 m.p.h.; a lot of metal must have come off the brake shoes. "The Dominion" came to a stand in Field at 1.25 p.m., the 14 miles from Stephen having taken 45 minutes, during which we had descended 1265ft. This speaks eloquently of the care and vigilance shown over this very difficult section.

Roughly 1320 gallons of oil fuel had been used between Calgary and Field, or 9·6 gallons per mile. The advantages of oil fuel are so great that the time will probably come when it will oust coal on locomotives; a trip on an oil burner will convert anyone to recognising its benefits, of which cleanliness is not the least. The cab of "No. 5924" was as clean as the boiler-room of a warship; there was no real need to wear overalls.

(To be continued)

The Coming Crisis in Electrical Power Transmission

By H. RISSIK, Hons. B.Sc. (Eng.), A.M.I.E.E., M. Amer. I.E.E.

No. II

(*Continued from page 350, May 30th*)

THE NATURE OF THE IMPENDING CRISIS

THE present situation in the sphere of electrical power transmission, then, is one in which an attempt has been made to overcome the limitation to further development imposed by considerations of system stability through the systematic application of fresh design principles to a basically orthodox technique. This attempt has been and, in the nature of things, can be successful only up to a point. For it assumes in advance the possibility of a continued and uninterrupted progress in the direction of higher transmission voltages, an assumption which seems hardly justified in practice unless transmission engineers should be inspired by Nansen's dictum that "the difficult is that which can be done immediately, the impossible that which takes a little longer." Even if this assumption proved to be a reasonable one, however, such an endeavour must inevitably and, in fact, quickly face a position in which, as the transmission distance is increased, economic considerations call for the transmission of powers in excess of those dictated by considerations of stability. This situation is illustrated by Fig. 3, for which the Boulder dam to Los Angeles transmission system has been taken as an economic datum. The two curves indicate the relations between transmitted power and transmission distance or transmission voltage corresponding, on the one hand, to a purely economic limitation (minimum limit) and, on the other hand, to the technical limitation of system stability (maximum limit). The shaded area between the two curves thus represents that zone within which both stable and economic operation of present-day transmission systems is assured.

It will be seen from Fig. 3 that if this commercially practicable zone of operation is to be

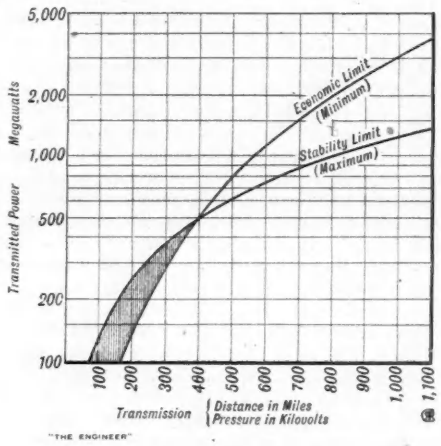

FIG. 3—RELATION BETWEEN POWER AND TRANSMISSION DISTANCE

extended in the direction of greater transmission voltages, one or both of two things must happen. Either means of raising the stability limit of transmission systems must be found or else some way of increasing the economy with which power can be transmitted will have to be discovered. Otherwise the progress of power transmission by means of A.C. at high voltages will stop short with transmission lines and interconnectors reaching some 400 miles in length and operating at, say, 440 kV. In which case a fresh impetus will inevitably be given to the use of D.C. transmission, a system in many ways ideal, but one whose implications have until very recently lain beyond the trend of current thought. That trend is best summarised in the words of a leading American authority on the subject of power transmission and distribution: "The present tendency continues to be toward the abandonment of the small steam station, the more complete development of hydro-electric power and the interconnection of the large steam and hydro stations by high-voltage networks. The development of long-distance transmission has been largely a question of practicable voltages. More recently, much attention has been given to the possibilities of direct-current transmission."

It is quite true—and has been realised, in a general way at least, for some considerable time—that the D.C. system offers an attractive way out of the approaching crisis in the evolution of long-distance power transmission, for it at once removes the stability limitation and increases the economy of transmission because much more power can be transmitted for a given degree of line insulation. At the same time, its adoption at this comparatively late stage in the evolution of electricity as the dynamic factor in technological progress would involve a complete revolution in the established order of electrical development. From the standpoint of distribution and utilisation especially, and perhaps that of generation also, such a revolution would be destructive of all the achievement of the past half-century and is thus quite unthinkable. On the other hand, in the narrower though increasingly important sphere of transmission, where some such revolution is becoming imperative in any case, the introduction of D.C. would create less disturbance than is generally supposed.

Before considering this possibility, however, or the alternative possibility of a radical change in the technique of A.C. transmission, it is pertinent to inquire whether the impending crisis suggested by Fig. 3 is a real one or whether it exists only as a theoretical phenomenon. What are the prospects of having to transport electrical energy in bulk over distances in excess of, let us say, 400 miles? In the event of its being politic to transmit power over such distances, would it not be more economic to transport coal or oil fuel to the site of consumption and there generate the necessary electrical power? The answers to such fundamental questions are, of course, conditional upon a maintenance of the present tendency towards universal electrification through nation-wide combinations of water and steam power stations and comprehensive transmission networks. As modern civilisation cannot afford to do without systematic electrification of this nature, for it constitutes the only really economic means (*i.e.*, economic in terms of human welfare rather than financial return) of a more widespread location of a nation's industries and industrial communities, there seems to be no doubt that this tendency will be maintained. That being so, it is clear that the known operating economies resulting from the interconnection of steam and hydro-electric generating stations will lead to a growing interchange of power on an international basis, with, possibly, the kilowatt-hour as a universal index by which national living standards can be readily compared.

As a matter of history this phase of electrical development is already under way. For some years past Sweden has been transmitting about 5000 kW to the Danish island of Zeeland (by means of a 25-kV, three-phase submarine cable between Palsjö and Marienlyst, a distance of 3½ miles), while before the present war plans were being considered for a transmission line from Norway through Sweden to Denmark, and thence to Germany, with the object of utilising from 1 to 2 million kW of water power at present going to waste. Switzerland imports electrical energy from foreign steam-driven generating stations during the winter months, when her native hydro-electric power is insufficient to meet home requirements, and exports her electricity surplus during the spring and summer. Canada annually disposes of some 1000 million kWh to the United States over a dozen transmission lines. Considering that in the great interconnected power systems of the North American continent power is often transmitted an aggregate distance of 500 or 600 miles when there is a local shortage of coal or water, it is more than probable that countries possessing surplus water power will in future export it in the form of electrical energy to load centres distant 1000 miles and more. In fact, to quote J. W. Meares, one of our foremost authorities on hydro-electric development, "there is much to be said for international electricity supply in preference to the export of coal." This observation naturally raises the question whether it is not, in fact, cheaper to generate the power where it is required. The view is commonly expressed that, when it comes to transmitting large blocks of power over these great distances, the alternative of transporting coal by rail or water and generating electrical power locally will be found, in the long run, to be the more economic course to adopt. That this view is entirely false has been convincingly demonstrated by Rüdenberg in a recent paper,* in which it is shown, for example, that the same unit cost of 0·05d. per kWh is incurred when transmitting 10,000 kW a distance of 50 miles at 66 kV; when transporting coal 100 miles by rail or 200 miles by water; or when transmitting 400,000 kW at 440 kV over a distance of 600 miles (which theoretically is just about possible, having regard to stability considerations). The position is summarised in Fig. 4, from which it is seen that the alternative of coal haulage is hopelessly uneconomic except for relatively short distances and correspondingly low values of transmitted power, for which transmission voltages below about 110 kV are appropriate.

We thus reach the inescapable conclusion that, short of a complete revolution in our present methods of transporting energy in bulk by means of A.C. at high voltage, there is no hope of being

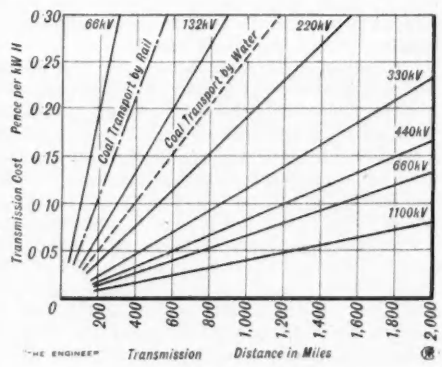

FIG. 4—TRANSMISSION COSTS

able to surpass transmission distances of the order of 400 miles. Even these distances can be reached only if and when transmission pressures of 400 to 440 kV prove attainable in practice.

THE POSSIBILITIES OF D.C. TRANSMISSION

The growing technical difficulties associated with the transmission of large blocks of electric power over steadily increasing distances have led, during recent years, to a renewed interest in the possible application of D.C. at high voltage for this purpose. In spite of the fact that A.C. lends itself readily to generation and voltage transformation in bulk, it cannot compete with D.C. where transmission on a similar scale is concerned. For this reason a D.C. transmission system can form, under certain circumstances, an economic link between the source of energy supply and the consumer. Although this fact has been known ever since A.C. began to displace D.C. from universal favour, in the last quarter of the nineteenth century, the advantages of D.C. transmission are, unfortunately, still largely theoretical.† No serious investigation into the practicability or otherwise of high-voltage D.C. as a power transmitting medium has taken place since 1912, when J. S. Highfield obtained some highly interesting data on the comparative flash-over values of insulator strings subjected to alternating and continuous voltage stresses, except perhaps the allied research of Professor Marx and his collaborators at Braunschweig, during the years 1930–32, on the rectification of super-tension A.C. A considerable stir was thus created in power transmission circles just over a year ago, when it was announced that the Bonneville authorities had entrusted Professor E. C. Starr, of the Oregon State College, with the task of investigating the immediate possibilities of D.C. at really high voltages for the large-scale transport of electrical energy over long distances.

Until the results of this investigation are made available the protagonists of D.C. transmission must perforce content themselves with speculations based on past achievements—in themselves by no means inconsiderable—and fortified, perhaps, by Lord Rayleigh's visionary statement of sixty

* *Vide* R. Rüdenberg, "The Economics of Very High Power Transmission Over Long Distances," *G.E.C. Journal*, 1938, Vol. 19, page 233.

† *Cf.* H. Rissik, "Some Aspects of the Electrical Transmission of Power by Means of Direct Current at Very High Voltages," *Jour.*, I.E.E., 1934, Vol. 75, pages 1–33.

years ago, which, in recording his joy at seeing A.C. coming in "because the whole world will now learn the subtleties of electrical science," expressed the view that "after that they will come back to continuous current." The most remarkable of these achievements remains, of course, the Thury constant-current system of D.C. transmission still in operation between Moutiers and Lyons. Although this unique transmission system covers an aggregate distance of nearly 300 miles, of which some 50 miles represents underground cable, the maximum operating voltage is only 125 kV, while the power transmitted does not exceed 20,000 kW, and hence it cannot be compared with present-day practice in A.C. transmission. Nevertheless, the Thury D.C. system has attractive possibilities, not least from the standpoint of generation. J. E. Calverley, probably the world's leading authority on high-tension D.C. machinery, considers that triple-unit double-commutator generators designed to give an output of 60,000 kW at 75 kV and 300 r.p.m. are a by no means impossible proposition. A hydro-electric station containing eight such machines would be in a position to supply some 500,000 kW at 600 kV, which could be transmitted at less than one-quarter the cost of the equivalent A.C. power.

Leaving on one side, however, the question of generating D.C. at very high voltages and narrowing the issue down to D.C. transmission only, the problem in its simplest form resolves itself into the provision of a D.C. link between a generating station and a distant load network, the former supplying and the latter demanding A.C. at 50 or 60 cycles. In this sphere of development the achievement is still insignificant. Granted that the rectification of A.C. to D.C. and the corresponding inversion of D.C. to A.C. are to-day accomplished facts which have revolutionised the supply of power to electric traction systems, yet the scale of current conversion attained so far is lamentably small when judged by modern standards of power transmission. At the same time, the successful demonstration of a 500-kW 50-kV D.C. transmission system employing mercury arc rectifiers and inverters at the Swiss National Exhibition in Zürich just before the outbreak of the war is a pointer to possible further development in this direction. Those fully conversant with the problems of static current conversion, however, incline to the view that the future of D.C. transmission is bound up with high-voltage current converters of the atmospheric-arc type, such as the air-blast arc converter developed by Marx, of which nothing further seems to have been heard since the remarkable series of field tests carried out at the Zschornewitz generating station of an important 110-kV power system in Germany in 1932. These tests went far to substantiate Marx's claim that a three-phase bridge-connected current converting unit of this type could be constructed to handle 250 amperes at 400 kV, corresponding to a throughput of no less than 100,000 kW.

Nevertheless, the fact remains that, practically speaking, nothing is known of the behaviour of D.C. at very high voltages. Many hitherto unsolved problems must be disposed of satisfactorily before the D.C. system can be put forward as a practicable solution to the impending crisis in the sphere of electrical power transmission. Voltage stress distribution in suspension insulator strings; the phenomenon of electrical endosmose in D.C. cables; the storage and dissipation of magnetic and electrostatic energy in high-tension transmission systems; the provision of suitable indicating, metering and relaying equipment; protection against lightning surges and other transient disturbances; high-voltage D.C. switchgear; electrolytic effects and system earthing. All of these are essentially practical problems which the protagonists of D.C. transmission have yet to face and overcome. Its overriding attraction is, of course, the inherent stability of any D.C. system of power transmission. Being entirely asynchronous in character, since the transmission frequency is zero, the problem of transmission stability no longer arises. It is for this reason, and quite apart from economic considerations in its favour, that D.C. transmission will continue to excite interest in power transmission engineering circles.

THE FUTURE OF A.C. TRANSMISSION

The fundamental problem facing the adherents of the A.C. system of power transmission is that of raising the stability limit of increasingly long transmission lines to economic levels. Unless this proves to be possible, then, as indicated by Fig. 3, the further development of long-distance power transmission must perforce come to an end with trunk lines and interconnectors some 400 miles in length and operating at, say, 440 kV. It is small wonder, therefore, that an increasing amount of attention has been paid in the last two or three years to devising means for overcoming the stability limitation inherent in the present method of electrical power transmission.

As is well known, it is the series reactance of a transmission line that, in the final analysis, limits the amount of power which the line is able to carry. Hence the problem of long-distance transmission is basically one of overcoming the power-limiting effect of this inherent reactance. Neglecting series resistance, which plays a very minor *rôle* in power limitation, the maximum power which can be carried by a transmission line under steady-state conditions without loss of synchronism occurring between its two ends is numerically equal to the square of the transmission voltage divided by the total line reactance. The stability limit of a transmission system is thus inversely proportional to its reactance; that is, to the product of transmission distance, inductance per unit length of line, and frequency. This product is, in effect, a measure of the "electrical length" of a transmission system. In other words, the longer such a system is electrically, the lower will be its stability limit.

Apart from the possibility of asynchronous power transmission—a mode of A.C. operation almost as revolutionary in its practical implications as the D.C. system—only two means of reducing the electrical length of a long-distance transmission system to manageable proportions appear as yet to merit serious consideration. Although the asynchronous *régime* of A.C. transmission is technically attractive, in that it is one in which the speed relation between the machines at the two ends of the transmission system is no longer fixed, but depends on the amount of power transmitted, so that it does away with the problem of synchronous stability, the use of induction generators employing A.C. excitation introduces a number of factors of practical importance tending to detract from the otherwise meritorious simplicity of such a transmission scheme. Therefore the most likely trend in the future development of long-distance transmission will almost certainly be in the direction of neutralising the power-limiting effect of line reactance, while adhering to the existing *régime* of synchronous transmission based on a standard frequency of 50 or 60 cycles. Here the choice seems destined to lie between the series compensation system, a solution which has been put forward at various times by American transmission engineers, and the unique system of dual compensation first proposed by a British consulting engineer, Major A. M. Taylor, in 1937.

It is but seldom realised that a transmission line requires excitation no less than a generator or a transformer. This excitation in like manner varies with the load and its supply must be catered for either by the synchronous machinery at the ends of the line or else by special apparatus provided for the purpose. The excitation requirement of a transmission line is, however, peculiar in that it includes charging as well as magnetising kilovolt-amperes, the amounts and relative proportions of which vary with the transmission voltage and the power transmitted. As the former kVA element represents positive and the latter negative reactive power, a little consideration will show that a condition of operation may arise in which the net reactive power demand of the transmission line is zero. This condition in fact defines the so-called natural load of a transmission system which can be shown to be of the order of $V^2/400$ megawatts, where V is the transmission pressure in kV. This characteristic value of transmitted power, corresponding to the minimum excitation requirement of zero reactive power, thus represents an economically ideal condition which, it is interesting to note, is satisfied by the majority of modern high-voltage transmission systems. Hence any reduction in the effective reactance of a transmission line, and therewith of the magnetising kVAr demand, in the interests of system stability, must be accompanied by a corresponding reduction in the charging kVAr demand occasioned by the shunt capacitance inherent in the line. Otherwise the economic balance between magnetising and charging kilovolt-amperes will be upset and additional means of supplying the difference will have to be provided.

This important factor in the economic operation of long-distance and thus high-voltage transmission lines is only too often overlooked by those who enthusiastically proclaim the merits of the series system of compensating unwanted line reactance. In this system the transmission line is artificially loaded with series capacitance. The voltage set up across the capacitors introduced into several or all of the sections into which a long-distance transmission line is in practice divided, is of necessity in phase opposition to the voltage drop in the inductance of the corresponding line sections. By installing a sufficiency of capacitors, both as regards number and kVA rating, the series inductance inherent in a transmission line can thus be neutralised to any desired extent. This novel method of line reactance compensation was first applied to an actual transmission system in 1928, when static condensers were installed at the Ballston sub-station of the New York Power and Light Corporation for the purpose of improving the voltage regulation of a 33-kV transmitting circuit. The success attending this installation led a few years later to an experimental investigation of the effects of series capacitors on the power-carrying capacity of a 250-mile line operating at 110 kV. The results of this study indicated that the power limit of such a line could be raised by no less than 113 per cent. All the same, there are a number of technical difficulties yet to be overcome before the series compensation system of raising the stability limits of long-distance transmission systems to economic levels reaches a practical stage of development. To quote from the "First Report on Power System Stability" issued by the A.I.E.E. Sub-Committee on Interconnection and Stability Factors in 1937: "In no major project in America has the series capacitor received serious consideration."

All such difficulties, however, pale into insignificance before the supreme problem of compensating the enormous charging currents taken by long high-voltage transmission lines—a problem which any series compensation scheme leaves quite untouched. For example, a 600-mile line operating at 440 kV takes a charging current of 700 amperes per phase, corresponding to a wattless load demand of no less than 530,000 kVAr. Such enormous demands for leading reactive power create unstable operating conditions in the synchronous generating plant at the line termini and hence tend to nullify the improvement in transmission stability arising from the compensation of excess line reactance. To relieve the generating plant of this unwanted and idle load some means of compensating the shunt capacitance of the line must be provided in addition; for example, by loading the transmission line at intervals with shunt reactors which would draw a current equal and in phase opposition to the charging current of the line. Such a compound compensated transmission system, in which the effects of magnetising voltage drop and charging current were completely neutralised through a concatenation of series (voltage) and parallel (current) resonant circuits, would behave as if it possessed resistance only and would constitute, in effect, the A.C. equivalent of a D.C. transmission system. The transmission line would no longer have any influence on the stability of the system as a whole.

The proposals of A. M. Taylor‡ for overcoming the power limiting effect of line reactance inherent in the present method of electrical power transmission, while of the same general nature, differ radically from the above in that the available charging kVAr of the line is itself used to compensate the magnetising kVAr demanded by the line inductance. Whereas a system of compound compensation employing series capacitors in conjunction with shunt reactors of necessity involves a duplication in kVAr loading, Taylor's system artificially promotes self-compensation of line capacitance and line inductance through the use of only a single form of compensating apparatus. This apparatus is nothing but a special type of transformer, the so-called reactance compensating transformer or quadrature booster, which, in effect, transfers the shunt capacitance between each phase and neutral of a section of the transmission line to the required position in series with the inductance of each phase of the corresponding line section. These quadrature boosters are so designed and their windings are so arranged that the secondary output voltage is in leading phase quadrature with the applied primary voltage, thus cancelling the inductive voltage drop in the line while the corresponding primary current drawn from the line is actually the charging current which

‡ British Patent No. 459,121, 1938; U.S.A. Patent No 2,180,264, 1939. For a brief description of the Taylor system of power transmission see, *inter alia*, H. Rissik, "Long Distance Power Transmission," the *Electrician*, April 26th, 1940, page 317; and A. M. Taylor, "Quadrature Boosters and Transmission," *ibid.*, May 31st, 1940, page 390.

would otherwise have to be carried by the line in addition to the power current. In other words, the basic function of the Taylor quadrature booster is to absorb the unwanted shunt capacitive kVAr and to deliver it in series with each phase where it can effectively compensate the equally unwanted inductive kVAr demanded by the line. This function is such that voltage resonance on the secondary side and current resonance on the primary side occur simultaneously. The transmission line is, in fact, artificially tuned by mutual compensation of its series inductance and shunt capacitance. It accordingly behaves as if it possessed resistance only, and the stability limitation to long-distance power transmission is consequently removed.

Apart from the technical simplicity of the Taylor system of power transmission—for it is virtually based on existing transformer practice—it is more attractive financially than a system based on compound compensation of line inductance and capacitance. The cost of quadrature booster transformers is of the order of 10s. to 15s. per kVA, while that of series capacitors and their associated connecting transformers, plus shunt reactors, in the aggregate amounts to from 60s. to 90s. per kVA—say, six times as much. For a 600-mile transmission line operating at 440 kV the capital outlay on quadrature boosters would thus be some £450–£650 per mile, as compared with, say, £2700–£4000 per mile for series capacitors and shunt reactors. The margin in favour of the Taylor system of transmission is therefore considerable, viz., from 60 to 80 per cent. of the capital cost of the line.

The inherent cheapness of the quadrature boosting transformer as a means of line compensation also renders the Taylor system economic in the case of relatively short transmission distances, through the greatly increased power transmitting capacity resulting from the ability to raise the limit of stable operation to any desired extent. A case in point is the interconnection of a number of scattered power systems in the interests of national security, when, in a time such as the present, damage by air attack, or even sabotage, might seriously curtail the industrial war effort through failure of a vital power supply. This point has very recently been taken up in the United States, for it is realised that under present circumstances there is a supreme need of being able "to stabilise the flow of power for industrial mobilisation to any point in the extensive area"—the area in question covering the counties of Montana, Utah and Idaho. The quotation is taken from a report in the American technical press of the interconnection of Anaconda and Grace by a 277-mile line designed to carry some 50,000 kW at 161 kV. This line will link up seven power systems to the north of Anaconda, having an aggregate installed capacity of 1¼ million kW, with nine power systems to the south of Grace whose aggregate installed capacity exceeds ¾ million kW. As a rough estimate, and in the absence of detailed information, the stability limit of this new interconnector is only in the region of 65,000 kW, so that its usefulness as a vehicle of emergency power interchange seems to be somewhat limited. Allowing the same working margin, however, the amount of power which might be transmitted by existing methods at 280 kV is 150,000 kW, a figure which could be increased to 210,000 kW by raising the transmission pressure to 330 kV. There seems to be a good argument for the use of a higher operating voltage than that originally envisaged for the Anaconda-Grace line, in that the proportion of the total connected power which could be released for immediate use in supplying new armaments factories is likely to be equal to the proportion of the aggregate installed capacity which is represented by spare generating plant—say, 250,000 kW in the north and 150,000 kW in the south. Unfortunately, the limiting power which, having regard to stability considerations, can be transmitted at these higher voltages is very much less than the power required in order that an excess of charging current—the bugbear of all high-voltage lines—may be avoided.

The accompanying table, for which the author is indebted to Major A. M. Taylor and Universal Power Transmissions, Ltd., indicates how this difficulty may be overcome, in the particular case of the 277-mile line cited above, through the use of reactance compensating transformers. The economic advantages obtained by being able to utilise the higher transmission voltages in this way are apparent at once from a comparison of item A, which refers to the conditions of operation of the Anaconda-Grace line as revealed by the American technical press, and item E, which represents about the most that can be achieved by the Taylor system allied with existing practice as regards transformers and line insulation. This last case, which considers the transmission of twelve times the amount of power as originally planned, also represents a maximum economy in that the annual value of the energy wasted in transmission is about equal to the annual capital charge on the line. At the same time, the transmission efficiency is practically the same as for the line as now actually planned. Finally, the last column of the table shows at a glance the profitability of the transmission line as measured by the ratio of the annual capital charges to the gross annual income earned. Although a 330-kV line designed on the Taylor system to carry 600,000 kW would cost more than two and a-half times as much as a conventional 161-kV line, its earning capacity would be twelve times as great and hence it represents a financial investment nearly five times as profitable. This is indicated by the fact that the annual capital charges would be only 2·9 per cent. of the gross annual income earned, as compared with a figure of 13·7 per cent. for the conventional case of item A.

"Mankind always sets itself only such problems as it can solve . . . ." In the sphere of electrical power transmission, at any rate, it would seem that in the Taylor system of line compensation we have the material conditions for an economic solution of the vital problem of neutralising the power-limiting effect of line reactance—material conditions, moreover, which (to complete the quotation) "are already present, or at least in process of coming into being."

Item.	Transmission voltage.	Maximum power transmitted.	Maximum transmission loss.	Equivalent copper section.	Current density.	Capital cost.	Cost per mile.	Cost per kW.	Annual capital charges at 7½%.	Annual value of wasted energy at 0·2d. per kWh and 50% load factor.	Gross annual income earned at 0·5d. per kWh and 40% load factor.	Ratio of capital charges to gross income earned.
	kV.	kW.	%	Sq. in.	Amps./sq. in.	£	£	£	£	£	£	%
A	161	50,000	16·3	0·091	1140	650,000	2350	13·0	44,800	12,000	364,000	13·7
B	280	174,500	9·0	0·182	1080	1,000,000	3600	5·7	75,500	22,800	1,270,000	5·9
C	330	212,000	16·6	0·091	2360	1,370,000	4950	6·2	100,000	60,800	1,545,000	6·5
D	330	300,000	11·2	0·182	1580	1,500,000	5400	5·0	113,000	69,000	2,184,000	5·2
E	330	600,000	15·7	0·273	2200	1,690,000	6100	2·8	127,000	160,000	4,368,000	2·9

The Iron and Steel Industry in South Africa

(By Our Own Correspondent in South Africa)

THOSE who desire to see the economic development of Southern Africa fostered, and wish to take part in it, are hoping that the industrial expansion which has marked the war period in South Africa, so far, will continue after peace has been restored. But if its progress is to be sustained, the advance must be made upon sound economic lines suited to the country's natural capacity for production. It must be well balanced. Particular activities must not be favoured in such a way that the development of other industries is hampered. And it must never be forgotten that South Africa's resources cannot be developed to the full under a policy that tends to make the cost of production unduly high.

Certain conclusions arrived at by Professor C. S. Richards, of the University of the Witwatersrand, and published by him in a book, entitled "The Iron and Steel Industry in South Africa," are so cognate to this subject that they will no doubt be studied by all concerned in it.

Professor Richards' book is a massive volume, containing the results of an investigation conducted over a period of four years into the operations of the Government-sponsored iron and steel works situated at Pretoria and usually referred to as Iscor Works. "Iscor" was established under an Act of Parliament in 1931; erection was completed in 1934, the various departments being started up in stages during that year. The initial capital of £500,000 was found by Government, but now, with the shares held by the public and debentures issued amounting to £1,500,000, the total capital is about £10,000,000, and the total annual output has been enormously increased, the annual profit exceeding a million sterling. Professor Richards' investigations included not only the operations of Iscor, but their influence upon the business of the Union and more especially upon the gold-mining industry. Much of Professor Richards' monumental report will appeal more to specialists than to laymen, but there are broad conclusions of major importance to the public generally.

Professor Richards does not deny the excellence of the Iscor plant and the efficiency of its management, but he severely criticises the system under which it disposes of its output. He says bluntly that it overcharges the consumer, and helps to maintain high prices, and so handicaps other industries. When the Union's iron and steel industry was launched, it was asserted that "natural protection" would be ample and that under it alone a concern would be able to produce cheaply and earn a profit. But practice did not follow precept. Dumping duties were imposed, and Iscor also entered into an agreement with the international Steel Cartel under which price levels were arbitrarily fixed, and were not competitive. This agreement, says Professor Richards, "should not be necessary, nor should it ever have been sanctioned by the Government. It has operated to the detriment of the whole country, has placed Iscor (and the whole steel industry) in the position of a privileged monoplist, has shielded it from virtually all competitive influences, influences which would compel it to increase efficiency and reduce costs and prices, and has enabled it to charge the mines, its principal customers, monopolistic prices. The fact that it has shown handsome profits since the agreement was implemented is therefore no measure of its utility to the country, but rather a measure of the extent to which it has overcharged, and is overcharging, customers in the competitive area."

Iscor, he says, was built to compete with and to fight the Cartel and to reduce prices, not to join it in a mutual policy of monopolistic pricing. Monopolies, he claims, are opposed to stated and implied Government policy, and certainly alien to South African ideals.

"For the Government therefore actively to entrench the steel monopoly is opposed to all principles of democratic organisations and the deliberate intention on the part of the Government of making it show a profit at any cost is wholly inconsistent with its expressed desire of reducing costs, increasing employment, and providing cheap steel. If the industry is to remain a private-public-State monopoly, then stringent control of its prices and profits should be exercised in the public interest."

Professor Richards gives figures to show that the gold mines have been consistently discriminated against, and he asserts that there is reliable evidence that the high price of steel is "reducing employment in the engineering industry and is leading elsewhere to the adoption of reinforced concrete in place of steel." Yet he is not opposed to the industry. The ore used is among the richest in the world. The coal gives good coke, and there is adequate flux. Pretoria was and is the best site. An iron and steel industry is essential to South Africa's development. His charge is simply that Iscor is charging higher prices for its products than it ought to do."

"Iscor was inaugurated on the ground that it would be a commercially sound competitive addition to the economic structure of the country. So far this has not been realised. It is simply another experiment which must, in addition to much of agricultural and many secondary industries, be carried by the country's economic activities, mainly gold mining. Nor can protected secondary industries be assisted to become economic if their productive instruments are directly or indirectly made too expensive.

The war broke out after Professor Richards had written his report, but although conditions have changed they do not persuade him to alter the basis of his indictment. He remarks that the war was indeed fortunate for Iscor, for it removed competi-

tion and restricted supply and raised import prices. He adds, however, that since the war Iscor "seems clearly to have realised its public character. It has not taken advantage of restricted competition to raise prices in the competitive area, and without it import prices to South Africa would at this moment, in the inland market in particular, be much higher." This policy, he hopes, will continue, and he adds: "But it is not difficult to adopt the mantle of public benefactor under such conditions, and it must be remembered that Iscor has still to justify the definite promises made for it years ago. Justification through war conditions is the adoption of an unsatisfactory economic criterion."

Professor Richards' indictment of Iscor's policy will no doubt receive the closest study from those who are keenly interested in the industrial progress of South Africa. For unless the raw material supplying concerns are based on the soundest economic principles, the Union's prospect of selling goods beyond its borders must be reduced, while there must also be a danger that the standard of living within the country would be lowered.

No reply has at present been made by any representative of Iscor to Professor Richards' criticism, but extracts from the annual addresses by Dr. H. J. van der Bijl, Chairman of the Corporation, since the outbreak of war in Europe, and reproduced hereafter, give a good idea of what Iscor has done for South Africa. Speaking at the annual meeting of shareholders on October 27th, 1939, Dr. van der Bijl said: "As was the case during the world steel boom in 1937, the benefits of the development of large-scale steel production in South Africa will be manifest to all in the face of the present crisis. Although South Africa's total steel requirements cannot be satisfied from local sources, it will be our endeavour to maintain steel supplies for essential requirements to help to minimise difficulties and dislocation of work, in the event of there being a shortage of steel in South Africa, and to maintain stability of prices as far as circumstances and conditions permit."

At the shareholders' meeting on November 27th, 1940, Dr. van der Bijl said: "To appreciate the effects of the war upon the steel position in South Africa, it must be remembered that South Africa normally imports about two-thirds of her requirements of steel products, the principal source of supply being Great Britain and the Continental Cartel countries. The outbreak of war in September, 1939, seriously interferred with deliveries of steel from Europe, and for several months there was great uncertainty in the local market regarding steel supplies, aggravated by steeply rising export prices for steel from any overseas countries and substantial increases in freight and insurance rates. In consequence, there was a rush from all over the country to place orders with the local steel industry—orders which in the aggregate were more than double the local industry's output capacity. In anticipation of this development we had, through our sales organisations, introduced rationing arrangements immediately after the outbreak of the war, so that we were able to keep control of the situation, and, in collaboration with many of the stock-holding merchants, to maintain supplies of steel for urgent purposes and to prevent stoppages of work and dislocation of business, which would in many cases have ensued, due to the shortage of steel supplies. When it became apparent that imports of steel products from Europe were likely to remain far short of South Africa's requirements, we took steps to assist in planning for imports from other potential sources of supply. We were instrumental in arranging imports from Australia and imports from Canada and the U.S.A. were also increased, with the result that relief was obtained in time to prevent more serious steel shortages.

"Since the beginning of 1940, and particularly from May last, the local steel industry has felt the effect of the progressively increasing development of the Union's war effort, and has been called upon to supply large quantities of iron and steel products, directly and indirectly, for defence purposes. For obvious reasons, I do not propose to go into any detail, beyond saying that we have for war purposes produced many products for which our works were not designed. In some cases methods of production and plant therefore had to be improvised, and great credit is due to the works executives for their unflagging efforts and ingenuity, and for the success which has been achieved, at very short notice, in producing various special steels and steel products not hitherto made in South Africa.

"There are two points in this connection that I would like to mention. First, that the Union's war effort in respect of munitions production, mechanical transport vehicles, the construction of hangars, camps, and other defence work, has only been made possible by the presence of Iscor, and that, apart from defence requirements, the ordinary business activities of the country would have been severely dislocated, and some of them brought to a standstill but for our local steel industry. While the establishment of Iscor, and the development of secondary industries which followed it, had as a primary objective the building up of peaceful industrial activity in South Africa, the events of the past year have once more demonstrated the advantages of the introduction and promotion of large-scale steel manufacture in the Union. Secondly, I would like to mention that with the large quantities of steel products required urgently for defence purposes, it has been necessary for us to disappoint many of our customers, large and small, who had come to rely upon us for their steel requirements. The demand upon us for urgent requirements for national purposes made it impossible to maintain full supplies to those accustomed to obtain steel supplies from us, and it became necessary to arrange with many of our regular customers to import considerable quantities of steel products and at very much enhanced cost. Whilst the necessity for doing so has been due to circumstances beyond our control, it has, nevertheless, been a matter of deep regret to your board and to your executives. I would like to take this opportunity of expressing grateful appreciation of the understanding of our difficulties displayed by our customers and of the co-operation we have enjoyed from them in our endeavours to help in regard to such importations of their steel requirements as has been necessary."

Dr. van der Bijl then referred to increased difficulties since June 30th, 1940, in maintaining steel supplies, owing to their having to take out of commission one of their two blast-furnaces for relining. This had caused a temporary reduction in output. To offset this the local steel industry has arranged to supplement local steel production by importing steel billets for re-rolling and re-processing in South Africa. These imported billets cost substantially more than locally made billets, and a temporary surcharge was introduced to recover the higher cost of the imported billets. There remained, however, a considerable saving to steel users, as compared with the cost of importing finished steel products from overseas, in addition to which it has been the policy of Iscor, notwithstanding increased working costs, to maintain the basic price of Iscor steel as far as possible at its pre-war level. He concluded by saying their immediate objective, as a "key" industry, "was to carry on with the work, to help in maintaining steel supplies for essential requirements, and, in collaboration, on the one hand, with the other units making up their local steel industry, and, on the other hand, with the general body of steel users, to help to minimise difficulties and dislocation of work due to shortages of steel supplies."

With regard to Dr. van der Bijl's remarks to South Africa being unable to produce more than a third of the steel required by this country, it may be stated that a large stride in production is being made even now. The additions to plant, &c., at Iscor, just completed, will increase the annual production by 100,000 tons, and a third blast-furnace which should be completed in this year will add at least a further 150,000 to 200,000 tons annually. It has also been decided to erect another large steel works, but, of course, it will be probably two years, if not more, before any supplies can be expected from that source.

Railways and Air Raids*

A SYSTEM of raid "spotters" has been introduced at all important places throughout the railway systems, and by means of either visual or audible signals the warning of imminent danger is given to the staff. Hundreds of railwaymen carry on even when danger is imminent.

During air raids all branches of the railway transport services operate as nearly as possible normally. One of the biggest problems of wartime on the railways is the necessity for complete black-out during the hours of darkness. In peacetime a great deal of railway work was carried out, including the movement of large proportions of goods and passenger traffics, by artificial lighting. Since the war many important railway places have been without light night after night for very long periods. Much experimental work was undertaken before the war to ascertain the best possible lighting conditions in railway marshalling yards, at passenger stations, and in passenger trains, and to determine the most effective methods of hooding electric signal lights, fogmen's fires, and the glare from locomotive fire-boxes. As a result of the examination of each individual locality, the rearrangement of electrical circuits, and the use of hundreds of miles of new wiring, reduced lighting under the control of master switches is employed to enable work to go on at selected centres. Special "Purple" warnings of air attacks ensure that these lights are extinguished during air raid "Alerts." The maximum permissible lighting is being provided in all goods depôts, marshalling yards, and railway stations, and on the trains. The lighting allowed on the railways falls within three main categories—normal lighting, "B" lighting with an intensity of 0·002 foot-candles, and "C" lighting of 0·2 foot-candles.

Just as fast as the enemy puts his high explosives or incendiaries down or causes damage to the railways by blast or *débris*, railway engineers are tackling the job of making repairs. Charts, maps, and drawings dealing with every detail of the railways' properties, including bridges, tunnels, lines, signals, telephones, lighting, and drainage, are consulted night and day by the railway engineering staffs who follow up every report received even when air raids are in progress and fragments of anti-aircraft shells and further bombs may be falling. Where necessary, breakdown gangs are instructed to report at dawn and materials are ordered from the nearest depôts. Generally, the most extensive bomb damage to the permanent ways has been repaired within twelve hours of its having taken place. Travelling cranes are always kept under steam, heavy timbers for trestles and girders in variety are kept in readiness on wagons for immediate conveyance to the site to repair damage to bridges.

The following are examples of speedy repair work:—As a result of an air raid, the crown of an arch in a shallow tunnel allowed earth to penetrate on to the tracks. Unfortunately, the soil continued to fall through until a hole showed at ground level above. A mechanical excavator was taken to the site, and 2000 cubic yards of earth removed above the tunnel; a new arch was built, the earth was then moved from inside the tunnel, when the line was reopened for traffic.

When a heavy-calibre bomb struck an electric conductor rail on a viaduct it glanced off, penetrated into the ground below, where it exploded, demolishing part of the viaduct. Two tracks on an adjoining viaduct remained intact. To enable services to be operated, a large high-tension cable diversion was made, a temporary cross-over, 200ft. long, was built, and automatic signalling over 2 miles of track was reversed, resulting in the train services being restored the next day. Meanwhile, the remains of the arches were demolished with the aid of a locomotive and wire cables. A special train, equipped with a large electric compressor was worked to the site and the demolition of the brickwork by ten heavy pneumatic hammers was put in hand. The whole of the brick *débris* was broken up and removed by lorries, excavation being undertaken to find a new solid bottom. The worst of the crater was dug out and the remaining weak ground was rafted over with steel rails and concrete. A trestle bridge of two spans was then constructed on the concrete raft, incorporated in the design of this bridge being a timber thrust member to take the end thrust of the remaining arches of the viaduct. Rolled steel joists with cross sleepers resting on them were provided for the rails. Hundreds of thousands of passengers have since passed safely over this place with only a slight check in speed to their trains.

During another air raid a high-explosive bomb penetrated the booking hall of a busy station, exploding on the track over the station subway. The blast from the bomb in the confined space was very severe. Rails, timbers, and girders over the subway were damaged, and portions of the platforms destroyed, whilst all the brick and tile constructions on the platforms were demolished, together with various kiosks. Numbers of cables under the platform nosing were also put out of action. Two ballast trains were at once rushed to the site, the loading of the material and the track repairs were carried out by gangs sent by lorries, with the result that the station was reopened and both lines were operating with temporary signalling the same day, less than eight hours after the incident occurred.

As experience has been gained of the effects, signs, and sounds of enemy raiders, railwaymen are rising to meet emergencies as they occur.

A wagon of ammunition fuses on fire was unloaded and saved by a checker and his gang; a train of ammunition and petrol was promptly moved away from a blazing building by a yard inspector; and a wagon of high-explosive bombs on fire was tackled by a shunter who, with other men removed a sheet and the topmost layer of bombs, which by that time were hot.

Not only railwaymen with many years of service and experience are rising to the occasion and showing their mettle. A young engine cleaner at a Midlands centre was acting as fireman on shunting engine duty at night when bombs began to fall. He put out incendiary bombs by using his hands and feet to cover them with ballast, and when a call for volunteers to drive a locomotive, not his own, to a blazing goods shed to draw a train of trucks to safety was made, he climbed up, took over the controls, and guided by the light of the fire only, set off. He made four successful trips altogether, the last three alone on the locomotive, and by the time the job was done the offside of the locomotive was too hot for him to touch. His coolness throughout the whole of the raid was praised by other railwaymen at the depôt. Another railway worker and a telegraph lineman, sent to make temporary repairs to seven important line-side wires, were warned to cease work owing to unexploded bombs in the vicinity. Both men continued working, however, and afterwards helped the Bomb Disposal Squad to remove two bombs from the neighbourhood of their telegraph wires to a river bank 500 yards from the tracks, thus enabling the passenger trains to be rapidly restored to normal working.

Railway clerks, supervisory staffs, and many other railway workers have also shown courage and calmness in carrying on their duties, applying their specialised knowledge and quickly adapting themselves to the rapidly changing circumstances of war. Steps have been taken to make records of acts of conspicuous gallantry and service, so that adequate recognition is made of acts of courage by the men and women of the British railways.

* Extracts from "Facts about British Railways in Wartime" issued by the British Railways Press Office.

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DESTROYING THE NIGHT BOMBER

IT is a cause for real satisfaction that each month now shows a growing total of night bombers destroyed. In the month of May the encouraging record of April was substantially exceeded, and it is reasonable to hope that we may be within sight of defeating this form of attack, just as during last autumn we destroyed so great a proportion of the daylight bombers as to bring that menace to an end, and with it the confident German plan for an immediate invasion of this island. In the Battle of Britain no fewer than 2375 German planes are known to have been destroyed, and it is likely that at least half as many again were so hurt as to crash when they tried to land. The personnel thus lost to the German Air Force cannot have been far short of ten thousand, whilst our total of killed and wounded airmen was less than one thousand.

What proportion of the attackers must needs be destroyed during each successive encounter in order to end an onslaught is a much-debated question. Some authorities take the view that 10 per cent. suffices; others suggest 15, but no one puts it higher than that. Inasmuch as from the days of ancient Rome the punishment of "decimation" has ever been held by armies to be fully deterrent, there is good historical support for looking on the former proportion as a reasonable one to take. Certainly it is a safe figure if one includes only the losses actually seen to occur; especially safe in the case of combats at night, when it is much harder to be aware of the fate of the damaged enemy and when the chance of such craft crashing on landing is at least double what it would be in daylight. A figure of 10 per cent. of night bombers seen to be destroyed may well represent not less than 20 per cent. of real losses, and no fighting force can continue to operate against such a mortality rate. To continue would mean that no pilot or other airman could expect to survive five raids, and would know that he would be more than likely to be killed within the first three. Certain nights in May when the enemy attacked in force showed percentage losses at this high level. Our men, it is true, were aided on the best of those nights by bright moonlight. That great satellite, like the minor satellite state of Italy, has changed sides between the two great wars, and is now our ally; certainly the advantage is to us! But, welcome as is the moon's aid, our defence is spreading in effectiveness over an increasingly large proportion of the month, and it will, we dare hope, increase steadily until every hour of the whole month is gravely dangerous to the enemy. From this account one must not omit those other important defensive aids—the anti-aircraft gun and the balloon barrage. The number of hostile aircraft accounted for by the former now runs into four figures, and although the main purpose of the barrage balloon is rather to prevent attack on particular targets by low-flying aircraft, equally useful work has been done by the destruction of a number of them. There are also "other means" which cannot now be revealed. It suffices to say that the captured crew of a German aircraft which recently crashed near one of our aerodromes had not the very least idea—then or now—of what it was that had destroyed their craft. Steady progress is being made, not only with these mysterious forms of defence, but with the accuracy with which our guns can be laid on unseen targets.

The effect of enemy losses on the scale now prevalent is serious, not only on the material side—the losses of aircraft—but even more so on the side of personnel. Only a small proportion of the population even of the hardiest countries is physically and mentally suitable for enrolment in the Air Arm, and with the present enormous output of new craft recruitment must become increasingly difficult. The immediate bottleneck is, in fact, the supply of human material rather than that of aluminium or oil. The growing losses of the personnel of the *Luftwaffe* means a steady lowering in the level of its men, both in personal quality as well as in experience and training. Subject countries may be dragooned into subservience to the enemy's war effort, but they cannot produce much help in respect of air personnel. Any large-scale endeavour in this regard would almost assuredly mean the desertion to our side of large numbers of pilots, probably with the aircraft allotted to them to fly. Nor would it be at all safe to entrust the building of aircraft to dragooned persons. Structural failures in the air would then become so common that the nerves of the pilots using them would be shattered. In the near future there will be little chance of the enemy competing with the Allies, especially with the growing aid of America, either in number or quality of aircraft or of the men who man them. To the defeated day bomber, we may hope to add the bomber that comes by night; both will be milestones on the road to air supremacy.

End of the Steel Age

A FEW weeks ago three well-known scientists expressed the opinion that the steel age was coming to an end! They looked forward to its demise with no outward signs of regret. It seems that steel has not behaved well to the scientist. One might almost say that it has cheeked them. Let them calculate, never so wisely, how strong it ought to be, it refuses to comply with their figures. It may be even hundreds of times weaker. Such lack of respect to self-approving brains is not tolerable. So they have decided that steel has got to go. It must be replaced by something that does permit physical science to postulate how it will or will not behave. One cannot have a mere material of industry carrying on with the abandon of a transcendental equation. It must obey the physical laws that wise men have conceived. No college of science can be expected to put up permanently with the existence of a material that presents insoluble problems. Steel must go. Something more amenable must take its place; something that is not cursed, permanently and incurably, with crystallisation. True it may be that even the single metal crystal conducts itself in rather unaccountable ways, but it is nothing like so refractory as a congeries of crystals, which is what steel is. No. Definitely the steel age must end. Steel must give place to a homogeneous material that has no vagabond manners, but behaves as the scientists say it ought to behave.

Providentially experience and history teach us that we need not look for a cataclysmal leap from the steel era into the next era. Hence we do not feel it our duty to advise shareholders in steel firms to unload at once. They will have time to turn round; possibly a few thousand years. If less than that at least long enough to remove any immediate anxiety. None of the ages of the earth has passed suddenly; overnight, so to speak. Long before it became the accepted practice to brain your rivals and relatives with a lump of bronze, an old stone or a new stone axe served the turn of those who held that what was good enough for their grandfathers was good enough for them. There was overlapping. Not hurriedly, in a few decades or less, as when the railway train ousted the stage coach, or the motor-car the horse, but with infinite dignity and circumspection the old stone age passed into the new, the new into the bronze, and the bronze into the iron. Of course, we moderns have *changé tout cela*. We run where bronze men ambled and stone men crawled. But even we cannot, in the twinkling of an eye, strip ourselves of a material that it has taken a few thousand years to acquire simply to satisfy the craving of the mathematical physicist for something that he can do sums about. He may be dunderheaded, but the practical man who has to make bridges or guns of steel is likely to continue to pay more attention to tensile tests than to the difference between the actual strength of the alloy and the strength that it ought to exhibit if it only had the decency to conform to the estimates of the physicist. Moreover, he will not unjustly retort that if the steel age has got to go something must take its place. The physicists and mathematicians want a homogeneous material; something that will not present them with the complexity of lattices and intercrystalline layers. Have they got it in mind? Something with the high and accommodating qualities of steel, but without its defects? Is it possible that they are thinking of plastics; that they foresee an age in which our bridges will be made of resin and our machine tools of glass? Or do they see visions of some new modification of metals, possibly of iron and steel, themselves, by which the crystalline formation will be removed and tensile strengths of colossal magnitude be attained?

But let us be fair. In the succession of ages through which man as a toolmaking animal has passed—the stone, the bronze, the iron—he has stepped from one to the other by accidental discoveries. It was not till the new steel age was reached that conscious efforts were made to produce better materials. And, if we disallow such fortuitous production of steel as is recorded in legend, the steel age, up to date, is infinitesimally short by comparison with its predecessors. In fact, it may be almost said to begin with Bessemer—less than a century ago. For it is mild steel rather than crucible steel that gives its name to this age. In that short period, and especially within the latter half of it, the advance in knowledge of the material and the technology of its production has been phenomenal. The rate has been so stupendous that it may be almost said that what it took thousands of generations to do in the bronze age we have accomplished in less than three. Looked at by the light of this crude mensuration it will be seen that there is no intrinsic impossibility in the proposition of the physicists that the steel age is drawing to its close. They may be right. It may be that before another century has passed steel will be no more than a secondary material, reserved for special purposes, as bronzes are now, and that the physicists of that day will be already foretelling the coming of yet another and newer age.

Obituary

LORD CADMAN

BY the death of Lord Cadman, D.Sc., F.R.S., on Saturday, May 31st, at Shenley Park, Bletchley, the nation has lost one of its most trusted leaders in both science and industry. The chairman of the Anglo-Iranian Oil Company, Ltd., and the Iraq Petroleum Company, Ltd., Lord Cadman was appointed in 1939 honorary adviser on oil to the Government. It was he who, in 1932, obtained for this country a renewal of the oilfield leases in Iran, while he took a leading part in the design and construction of the great oil pipe lines across the desert from the Mosul oil wells to the coasts of Palestine and Syria. He was born on September 7th, 1877, at Silverdale, in the county of Stafford, and was the son of the late Mr. J. C. Cadman, M. Inst. C.E. Beginning his education at Newcastle-under-Lyme, he proceeded to Durham University, where he graduated in science, receiving the D.Sc. degree. His first work was connected with the mining of coal, and he became the manager of the Silverdale Colliery, North Staffordshire, at the early age of twenty-three. The following year he entered Government service and became one of H.M. Inspectors of Mines. In that office he served in the East Scotland District and later in the Staffordshire District. While in Scotland he came into touch with the Scottish oil industry, with its shale mines and refineries.

In 1904 Dr. Cadman was selected to assist the Government in certain adjustments in wages and working conditions, and the settlement of disputes connected with the Trinidad oil industry. While in Trinidad Cadman organised a Mines and Petroleum Department, which gave an impetus to the development of those industries in the Colony. On his return to England in 1907 he was invited to serve on the Commission on Mines, and in the following year, 1908, the work of the Commission being completed, he returned to his post as Inspector of Mines.

In 1910 the University of Birmingham appointed Dr. Cadman Professor of Mining, and it was at Birmingham that he introduced a Department of Petroleum Technology, which definitely connected petroleum technology with the mining engineering curriculum, and was the first of its kind to be organised in a British university. Dr. Cadman held that post until 1920. Three years after taking up his work at Birmingham he was selected by the Admiralty to join a special Commission, which was entrusted to report on the Iranian oilfields before the Government decided to take a financial interest in the undertaking. It was on that occasion that Dr. Cadman came closely into touch with the Anglo-Persian Oil Company, Ltd. The last war broke his ordinary work for a time, during which he served in the Army in the chemical section dealing with trench warfare. At a later date, when the oil position became serious, Dr. Cadman was invited to occupy the chair of the inter-Allied Petroleum Council, which was entrusted with the provision of Allied oil supplies. In that position he contributed vitally to the means which brought about the successful end of the war in 1918.

It was in 1921 that he joined the Anglo-Persian Oil Company, Ltd., in the capacity of technical adviser, and soon afterwards he was made a director of the company. His value soon became apparent, and he was soon made deputy chairman of the company and became its chairman in 1929. Apart from the work of his company, Dr. Cadman found time for many other important industrial interests and much work of national importance. He was a director of the Great Western Railway Company and the Suez Canal Company, and was also as, already mentioned, connected with the Iraq Petroleum Company, Ltd., occupying the position of chairman. In that capacity he played a leading part in the design and the completion of the oil pipe lines from Mosul to the Mediterranean Sea, which were finished in 1934.

His work on Government Committees was heavy, and, among other appointments, he was a member of the Prime Minister's Economic Advisory Council, the Scientific and Industrial Research Council, the Safety in Mines Board, the Fuel Research Board, the Coal Advisory Committee, and the Committee of Inquiry into the Post Office. His scientific interests remained unabated. He was Vice-Chairman of the Bridgeman Television Committee and at different times he served as President of the Institute of Petroleum Technologists, the Institution of Mining Engineers, the Institute of Fuel, and the Society of British Gas Industries. He was Consulting Petroleum Adviser to the Government and late Director of H.M. Petroleum Executive. His work for the nation was honoured by the bestowal by his Majesty the King of the C.M.G. in 1916, the K.C.M.G. in 1918, and a G.C.M.G. in 1929. In 1937 he was raised to the peerage and took the title of Lord Cadman of Silverdale, in the County of Staffordshire, where he was born. Abroad his worth was recognised by the bestowal of further honours. He was decorated with the First Class Order of the Rafidain and was Pasha, First Class, of Transjordan, a Grand Officer of the Legion d'Honneur, and a Knight-Commander of the Crown of Italy. He was elected a Fellow of the Royal Society in 1940, was an honorary LL.D. of Birmingham University, and an honorary Dr. Eng. of Melbourne University, Australia.

To those who knew him personally the death of Lord Cadman at an early age has come as a great shock. Always full of energy and in appearance young for his years, one never thought that the country would be deprived so soon of his great services. He wore the honours and dignities that

LORD CADMAN

came to him lightly and to the end remained to his friends just what he had been in his youth. He gained the great positions he held by sheer merit and ability combined with a genius for work, but with those qualities were joined a personal charm and unpretending cordiality that endeared him to those fortunate to enjoy his friendship.

Literature

Steam Power Stations. By GUSTAF A. GAFFERT, Sc.D. Second edition. 1940. London: The McGraw-Hill Publishing Company, Ltd., Aldwych House, W.C.2. Price 31s. 6d.

THE justification for the many books on power station practice lies in the extent of the ground to be covered and in the rapidity with which new developments make earlier books obsolete. The present volume, now in its second edition, is primarily designed, according to the Preface, as a text-book for American college students. It can be described as a review of apparently every kind of mechanical apparatus, whether fixed or moving, that is likely to be found in or about a power station. But even this does not exhaust the contents. Such matters as boiler feed waters and their treatment, fuels and their combustion, load curves and plant location, and the thermal cycles of stations, also come in for consideration. Furthermore, as in many American books of the kind, the financial as well as the technical aspect of power station design is definitely brought home to the student. With such an immense mass of material to be dealt with in less than 600 pages, it would be unreasonable to expect much detailed information on any subject, yet the compression has, on the whole, been very judiciously done, and the reader having been told what kind of equipment exists and roughly how it works, can easily supplement this knowledge by consulting more specialised treatises.

Prime movers, ranging from the simplest type of reciprocating engine to turbines of the largest sizes, are disposed of in less than 60 pages. The vertical high-speed engine, so common in this country, is not even mentioned, and one gathers that horizontal Corliss and Uniflow engines hold the chief place in American practice. The steam turbine section is somewhat sketchy, but attention is arrested by the statement that "3600 r.p.m. machines have now been built up to 60,000 kW capacity." A student would certainly take this to mean that manufacturers had already built turbines of the ordinary type driving single generators of the speed and output mentioned. It seems probable, however, that the author had in mind multi-shaft machines, such as the 60,000-kW compounded turbine at the Windsor station of the Ohio Power Company. The largest straightforward high-speed turbines in the British Empire are a pair of 50,000-kW, 3000 r.p.m. Parsons sets at Sydney, N.S.W., and few makers would care to exceed this output at 3000 r.p.m., to say nothing of 3600 r.p.m.

The illustrated descriptions of apparatus which form so large a part of the book are in many cases obviously based on manufacturers' literature. There is nothing blameworthy in this, for who should be better able to call attention to the important features of any article than the makers of it? The selection, moreover, is good, the presentation unbiased, and the descriptions informative and eminently readable. Indeed, the whole book can be read with interest and pleasure. This is a valuable feature in a text-book, for when information is offered so that it can be pleasantly absorbed, half the work of the teacher is done. The chapters dealing with Steam Station Costs, Load Curves and Plant Location, Selection of Prime Movers and Boilers, Choice of Cycles, and Station Design give the student a good insight into the larger problems of power station engineering. These, and all other chapters concerned with matters involving calculation, are followed by a number of questions by which the student can test his knowledge, but, as in practical life, the answers are not given.

There is an interesting chapter of 26 pages on binary vapour cycles, in which the merits of mercury, di-phenyl, di-phenyl oxide, aluminium bromide, and zinc ammonium chloride, as the high-temperature liquids, are considered in turn. Of these substances, the author favours mercury, but although this cycle has been the subject of development for nearly twenty years, it seems that only three plants are yet in operation, and little has been heard of their success. No one doubts the theoretical advantages of the mercury-steam combination, but since, according to the author's estimate, a 50,000-kW turbine would require about 90 tons of mercury, and the total annual world production has never exceeded about 5500 tons, the competition for the supply of the metal might easily become acute.

There is very little in the volume that calls for criticism. It may be pointed out, however, that water is never "injected under pressure" into a barometric condenser; the vacuum draws it in quite fast enough. Again, the remark that "turbines of the vertical shaft type were developed first," applies, of course, only to the early Curtis machines of the American General Electric Company, and these did not make their appearance until Parsons had been building horizontal turbines for nearly twenty years. Furthermore, while it is true that the vertical Curtis turbine was not abandoned in America until after 1914, horizontal machines were being built in Europe under the Curtis patents at least as early as 1908. A certain light-heartedness with regard to dates is also shown by the remark that Edison's first American power station at Pearl Street, New York, was started in 1880; the actual date of starting was September 4th, 1882. Nor did Watt invent his steam engine in 1776; his master patent was taken out in 1769, and in 1775 he was granted an extension of it by Parliament. These, however, are small matters, and are only mentioned in the interests of accuracy. The book does not pretend to be a history, but an account of modern American power station practice suitable for the needs of a student, and as such it is to be commended.

NEW SWEDISH MOTORSHIP.—News has just been received of the launch of the "Sven Salen," a 9050-ton cargo motorship which is being built by Eriksbergs Mek. Verkstad, Gothenburg, for Rederi A/B, Jamaica. The ship is of the shelter deck type, the main dimensions being 432ft. 3in. overall length, 56ft. 6in. in breadth, and 28ft. 9in. in depth to the main deck.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents.)

STEEL *v.* COPPER FIRE-BOXES

SIR,—I was very interested with perusal of an article appearing in your journal of September 13th last, dealing with steel *v.* copper fire-boxes, and desire to make certain remarks and suggestions which may be of service to your railways.

As you are aware, all locomotive specifications insist on "copper plates" containing a certain percentage of arsenic, as a hardener, but since the adoption of the electrolytic process of manufacturing such item has been absent hence the unsatisfactory service.

Some thirty-five years ago, when discussing the position with the late Mr. A. L. Beattie, who was then the C.M.E. of the New Zealand Government Railways, I pointed out that he would not find a copper fire-box in U.S.A. or Canada, but that steel plates were universally used. My friend finally decided to order six sets of plates for trial from Lumen's Steel Company, Philadelphia, and the results have proved so satisfactory that such make of plates is still standard practice with N.Z. railways. I might add that I have never—nor have I now—any personal interest with such maker, and there are probably equally reliable makers of similar plates in America.

I understand that the merit of such excellent service is that a certain amount of copper is included in the steel melting, but whether in electric or open-hearth furnaces I am not prepared to say.

I might also mention that the late Mr. Thow, C.M.E., New South Wales Railways, made a trial, some forty years ago, of steel plates from the Steel Company of Scotland, but they failed by cracking.

Some fifteen years ago I persuaded Mr. Smith, then C.M.E., Victorian Railways, to equip a batch of ten goods engines with Lumen's steel fire-boxes, and, being interested in their performance, I addressed his successor, Mr. Harris, concerning, and for your information enclose his reply, which certainly does not condemn steel plates which, I presume, are Lumen's.*

I note from THE ENGINEER of December 16th, 1927, page 677, that the South African Railways have, for some considerable time, used steel fire-boxes and contemplated the general adoption of same; query maker of plates.

Further, from your journal, July 7th, 1940, welded steel fire-boxes and flues now standard practice on French Government Railways.

I note also a very interesting article in your issue, Supplement, August 26th, 1927 (note also your sub-leader of November 30th, 1928), "Corrosion Resistance of Copper Steel," which, while not directly bearing on the foregoing, is worthy of re-perusal.

Incidentally I might mention that some forty years ago Howell's copper-coated steel tubes were adopted by the New Zealand Railways, but abandoned owing to the "copper coating"—electrically deposited—peeling off; otherwise this would be the ideal boiler tube.

Please note that your article of August 26th, 1927, states one million tons of copper steel plates were made in the United States in 1925; it points to such commodity being largely used for locomotive fire-boxes, and I assume that owing to the demand for same being so small in Great Britain no steel works can be bothered by such commodity, even in peace-times.

W. PALMER.

Auckland, N.Z.,
March 28th.

FACTS ABOUT THE RIFLE

SIR,—The article on the rifle in your issue of May 10th must have been read by many with the greatest interest, but there are two points on which further information and explanation would be welcome.

It is stated that an observer situated 1000 yards down the range hears the "crack" of the bullet for two seconds before the arrival of the sound waves of the "plop" or explosion which left the firing point at the same time as the bullet. But as the bullet arrives at the 1000 yards point in just over two seconds and the "plop" sound waves arrive in about $2\frac{3}{4}$ seconds it would appear at first sight that the "crack" should last for little more than half a second. Again, if the reduction of air resistance to the passage of a bullet when its velocity falls below that of sound is so "extraordinary," as is suggested in the article, there must be a fallacy in the commonly held explanation that below that velocity the compressed air in front of the bullet travels away in waves faster than the bullet itself, whereas above that velocity the bullet is overtaking the waves of compression and the resistance increases as if the bullet were travelling through an atmosphere of compressed air.

J. T. EVANS.

Radcliffe-on-Trent, Notts,
May 20th.

SIR,—I have to thank Mr. J. T. Evans for pointing out an obvious error in my article. As he rightly states, the crack of the bullet will be prolonged for about 0·7 second only and not 2 seconds.

With regard to his second point, the word "extraordinary," I think, may fairly be used to describe the very sudden change in air resistance that takes place when the bullet passes through the velocity of sound, inasmuch as one unfamiliar with the phenomenon would certainly be astonished on observing it for the first time, and would also be puzzled to find a satisfactory explanation. It is doubtful if even to-day a completely satisfactory explanation has been formulated.

If the popular "motion in compressed air" explanation mentioned by Mr. Evans did account for the facts, this would certainly merit the term "extraordinary." It would necessitate the sudden development round the bullet of a compressed air envelope about three times the pressure of that existing just below the velocity of sound.

The bullet always compresses the air ahead of it and when the velocity is below that of sound the compressed air is transmitted away from the nose in all directions as soon as it is formed. When, however, the velocity of sound is exceeded, all directions "ahead" are at once denied to the compressed air, and it has to get away in a much restricted space. As a result a very pronounced "shock wave" is formed bluntly conical in shape, and radiating outwards and somewhat backwards from the nose of the bullet. This wave, together with subsidiaries from the base of the bullet—the origin of which is not fully understood—have been photographed by Cranz and other experimenters, and reproductions are given in Professor Bairstow's book on "Aerodynamics" and in "The Mechanical Properties of Fluids," by F. R. W. Hunt. The angle of the cone becomes smaller as the velocity increases and can be used as a means of measuring the instantaneous velocity.

The result of the restriction in the escape of the air is that the bullet is virtually pushing a cushion of air continuously ahead of it and so the resistance to forward motion is enormously increased. The bullet is not, however, passing through the compressed air cushion, for the air is streaming away in a bluntly conical direction, whilst the "cushion" is being continuously replenished. Experiments by Professor Bairstow indicate that apart from the great intensification of pressure on the comparatively small area at the nose of the bullet the average air pressure over the whole surface of the bullet does not change widely in passing from below to above the velocity of sound, hence the theory based on motion in an envelope of compressed air is untenable.

I would take this opportunity of pointing out an unfortunate omission in the article as printed. At the top of column 3, page 331 (Part II of the article), the values of the "strength factors" corresponding to the various wind speeds are not given. These should be 1, 2, 3, 4 and 5, corresponding respectively to 4, 8, 12, 16 and 20 m.p.h.

D. WEIR.

May 28th.

WAITING TIME

SIR,—Waiting time is in the spotlight, but much of it is shaded by bonus times or piecework prices which have been arranged by haggling on no firm basis of accurate observations and records. Moreover, observing and recording are not by themselves enough, for the observer must have the power to change workshop conditions which are unsatisfactory if he is to do his job properly. Hence he must be possessed of the requisite practical knowledge and have been trained to apply it.

The usual excuse when a management is accused of tolerating bad rate fixing and inefficient conditions is "there'll be a strike." That is nonsense. All the facts are set down in detail for discussion and agreement when the transaction is properly done, and experience proves that this way is more satisfactory to everybody concerned than any other.

While some waiting time as a regular shop condition is often allowed for in bonus prices, a large part may be openly booked, but more often is hidden in some form of daywork, *e.g.*, repairs or experiments. To minimise that a manager needs help from the cost office and satisfactory explanations from those foremen and rate fixers responsible for sanctioning questionable bookings.

Much waiting time is due to working an unbalanced shop for excessive hours and a good deal of overtime (particularly on Sundays) is worked by members of the staff, as well as shop mechanics, to win approval from superior officers (who should know better) or to augment pay (for which in normal times there may be excuse). Everybody knows of instances where work has been held back to make overtime seem necessary; the retard is infectious and the disease spreads. Ultimately the sluggish state is regarded as normal health.

A point worth considering is whether overtime and Sunday working should be paid for at a higher rate during the war and whether salaried workers should be paid for overtime. Cessation of these practices would have a remarkable effect on hours worked and yet output could be improved at the same time if every man always had plenty of work to go at. That is almost entirely a question of planning well ahead—management.

In this connection insufficient use is being made of simple line charts. They are very helpful when arranged to show visibly in juxtaposition what is aimed at and the actual performance. There is no need for elaborate affairs requiring draughtsmen and crayons. But success depends on looking both near and far ahead and being provided with accurate information. As a rule one gets the kind of information one deserves.

A. C. WHITEHEAD.

Derby, May 28th.

[* Mr. Harris says that steel plates are unsatisfactory in Belpaire boxes with waterlegs inside the frames, but he proposes to use steel for wide fire-boxes. That confirms British experience. —ED., THE E.]

Sixty Years Ago

THE EDUCATION OF ENGINEERS

WITH the dawn of the railway era in or about the year 1830, men woke up to the fact that a new calling, engineering, was open to their sons. The practice of placing young men as "articled pupils" with civil or mechanical engineers soon arose and fees of five, six, or even eight hundred pounds were sometimes paid by wealthy parents as premiums for their sons. Very frequently the pupils were allowed to do much as they pleased with their time, and systematic attempts to instruct them were seldom made. A classical story used to be told of one pupil who, after spending three months screwing bolts, protested to his foreman and agitated for a change. At the end of a further three months the change came. He was put on to screwing nuts. Many of our best and greatest engineers limited the number of their pupils or refused to take any at all, until at last it became apparent that the English engineer, denied proper training facilities, was likely to be the most ignorant engineer in the world. Then a change set in. Glasgow, Dublin, and London Universities established Chairs of Engineering. In time degrees in engineering began to be granted, and the belief soon spread that highly trained and competent engineers could be manufactured in colleges. In our issue of June 10th, 1881, we sought to combat this idea, an idea which, we said, was still prevalent in certain quarters, notably in the Indian Government. The arguments which we developed need not be recapitulated. It is sufficient to say that we contended that theory was but one half of the education of an engineer, that practice was the other half, and that if only one half could be obtained it should be practice. We argued against the instructing of engineers in the higher mathematics. If problems involving abstruse mathematics arose, as, for example, in the designing of large bridges, it was far better and more convenient for the engineer to submit them to a professed mathematician than to attempt to grapple with them himself. The engineer who was also a highly trained mathematician was, we said, usually quite unfit for practical work. As an instance of the troubles which arose when engineers became too mathematical we mentioned a large lattice bridge in France, the calculations for which occupied months, and resulted in a specification in which the dimensions of the various members were stated to the hundredth part of an inch. No iron manufacturer would guarantee to roll bars to this degree of accuracy, and no bridge builder would undertake to plane them all over at a reasonable price. The bridge was not built until the specification was relaxed, a process involving the waste of months of elaborate calculations.

PROTECTIVE COMPOUND FOR PERSPIRATION DAMAGE.—A compound, known as "Ply No. 9," developed by the Milburn Company, of Detroit, is claimed to eliminate damage to highly finished parts by perspiration on the hands of workmen. The *Machinist* states that this compound is a water-like, colourless solution, into which the workman dips his hands, and as it dries a fine invisible film forms, protecting the man's hands and also the product on which he is working. It is claimed that there is no detrimental effect on the skin and that the compound can be easily removed.

Financing Exports of Specialised Manufactures

By W. W. SYRETT

A LARGE proportion of the export trade of the United Kingdom consists of manufactured products. The pre-war tendency was for the value of capital and quasi-consumption goods coming within this class to assume a larger percentage of the total, and the post-war trend may well be towards an acceleration in the same direction. In countries formerly limiting their industries to primary products, recent developments have shown the importance of secondary industries in the struggle towards balanced economy. The newer industries at once provided a market for certain classes of machinery exported from England and the United States, but left the importing countries concerned with the problem of exchanging a growing surplus of primary products for a range of imports lessened by the classes of consumers' goods now home-produced. Under these circumstances it is logical to plan upon the basis of both an assured and widening market for specialised manufactures, and, basing the forecast upon a raised standard of living in the markets and upon favourable terms of exchange, there is at least a reasonable hope of covering production costs by selling prices, even if home charges are raised by the expense of post-war reconstruction.

The last decade in exporting has found producers growing conscious of a range of risks for which no terminology previously formed part of their vocabulary. In other words, they have had to cope with a range of exchange, credit, transfer, and strategical hazards arising from the political instability of the times. These risks were always present, but had not previously been recognised in concrete terms; they were, in fact, often so remote as to be ignored. Under present circumstances the financing of exports is not merely a process of finding an overseas buyer who will pay the price already fixed for a product, nor even of attempting to produce at a figure which the potential buyer can be educated to disburse; the financial process has become one of assessing the newer risks in monetary terms by either insuring, where possible, or boldly assuming chances which would have frightened a previous generation out of business.

As far as specialised manufactures are concerned, finance becomes more involved than it does for branded or standardised products, first, because of the greater length of time elapsing between initiation and final consummation of the sale contract, and, secondly, because of the more restricted market for specialities outside that from which the order is received. For some manufactures of this class, failure to secure effective payment from the purchaser means that the output so laboriously produced becomes junk and nothing more, and must be written off as a loss of the magnitude of something over 90 per cent. The financing of exports falling within this classification thus becomes, even more pronouncedly than for general production, a matter of clear recognition of the risks involved, followed by the greatest feasible degree of elimination of them.

The only method of covering 100 per cent. of the hazards is by prior payment to the manufacturer; that is, by "cash with order." If such a condition were imposed in all contracts for sale of goods, it would be quite impossible to continue production at its present level, owing to the insufficiency of the volume of currency. There are, however, several possible alternatives which it is proposed to examine in relation to the risks peculiar to specialised production. These alternatives vary through a range of media, *i.e.*, involving the intervention of intermediaries—the banking, merchanting, and insurance mechanisms, and facilities offered by Government Departments—or by the system of setting up reserves for contingencies by the producer himself; any or all of these alternatives may be employed separately or in collusion.

The credit risk is one that has always been fairly clearly recognised. The risk that the buyer may become insolvent is variously guarded against by passing export orders through merchant or confirming houses, by insisting upon finance through bankers' irrevocable credits, by insuring with commercial insurers or with the Export Credits Guarantee Department, and by the "spreading" of the hazard over a wide range of purchasers. In some industries (*e.g.*, in special types of automobiles and radios evolved to meet the needs of export markets), the risk is normally carried by the distributive mechanism rather than by the producer; but where the manufacturer undertakes the distributive function through his own export department, the insolvency hazard is minimised by stipulating cash on delivery to retail purchasers, by selling to a number of wholesalers, whose credit status is kept constantly under review, and/or by collaboration with hire-purchase houses, in the market, who provide one or other of these safeguards.

The examples employed in the last paragraph are those in which the specialisation results from the research of the manufacturer, who has evolved a mass-production standard to meet the needs peculiar to climatic and other conditions in the market. At the other extreme lies the "overseas specification" type of product, in which the initiative of definition lies with the purchaser and not with the manufacturer. Many instances are provided by a casual glance at the advertisements in the journals catering for engineering trades. These range from products built up from standard semi-manufactures without specialised machinery to things which require exceptional grades of materials passed through non-standard machinery for their completion, and "jobs" which entail the dispatch of technicians to the site.

The semi-standard manufacture is generally best financed by means of a slight adaptation of the normal methods. According to the relative bargaining power of the parties and the credit status of the buyer, so the contract signed between them may vary. Some exporters may be in a position to secure a percentage of cash with order, with the balance payable upon shipment or upon delivery, such balance being secured perhaps by bankers' credits, or by the intervention of a *del credere* agent. According to the nature of the export and the limits of deviation permissible under the specification, so the contract may be varied to leave a final percentage for payment after test by the purchaser or by a third party appointed for the purpose. The longer the period of manufacture and the greater the degree of specialisation, the more important it becomes that the manufacturer establish what is termed in financial circles a "secured basis" regarding eventual payment.

The highly specialised product, which is contributing increasingly to the quantum of United Kingdom exports, usually lends itself to finance by "progress payments." In some cases, though by no means usually, the purchaser may take a financial interest in laying down the plant. In other cases the contract is initiated by a percentage of cash paid over. During the course of manufacture, inspection by an independent expert, at agreed stages or after agreed periods, provides a basis of certification upon which the intermediate increments can be paid over to the nominee of the producer. Advances by bankers can usually be arranged where necessary to meet disbursements for materials and labour. A system of this type was not uncommon in shipbuilding before the war, and munitions production is at present being financed on a somewhat similar basis. The final consummation of the production contract is usually provided for in the contract itself, which defines the stage at which the export is to be considered complete, and any related maintenance or service contract is to commence.

Recent innovations affect both the transfer and exchange risks inherent in specialised production for non-resident purchasers. The transfer or "frozen asset" difficulty can be avoided, as to a substantial percentage often as high as 90 per cent., by the facilities of transfer-risk insurance offered by the Export Credits Guarantee Department. It would hardly be feasible to comment with brevity on the facilities offered, particularly regarding projects involving protracted gestation, since each "proposal" is considered upon its individual merits. Medium-term finance is a specialised realm, in which the hazards can seldom be reduced by a foreshortening of the period of uncertainty. The chances are of a political flavour; many markets which involved the highest degree of hazard in pre-war days are now no longer attainable owing to strategical developments.

The Payments Agreements concluded by the United Kingdom in the past few months provide for sterling settlement of trade debts. The general effect has been to eliminate the exchange risk inherent in fluctuating exchanges, because present quotations are made in terms of U.K. pounds. For trade between the major currency areas (U.S.A. dollars and sterling) it remains permissible to price exports in foreign currency, but forward exchange facilities are available through bankers. It must not be ignored that debtors have in the past pleaded exchange fluctuations as an excuse for avoidance of the strict payment terms of contracts expressed in sterling, and it is therefore wise for such contracts to be clausedto the effect that variations in exchanges provide no grounds for reconsideration of agreed prices.

The mere fact that trade with a foreign country is priced in sterling, and paid for through the "Special Account" payments mechanism, does not eliminate the transfer risk. The course of trade may prove adverse to the country in which the buyer resides, and even present gold reserves in that country's beneficial ownership are no full guarantee of capacity to transfer at indefinite future dates. Where there are political elements involved, as with Spain, or where the purchaser resides in a state contiguous to enemy-occupied territory, it becomes the more important either to insure through E.C.G.D. or to take orders only through a merchant having two-way trade and right of offset.

A consequence of the fact that Britain and British waters have become "combat zones" is that exporters who formerly based contracts on f.o.b. values have had to extend their terms and assume what are called the "c.i.f. risks." Constructional engineers, who would normally clause their contracts to provide that buyers pay freight, insurance (including war risks, replacement costs, &c.), *force majeure*, and other contingencies, are now being asked to assume the freight and insurance costs. It does not suffice merely to advance the former price by estimates based on present freight and insurance rates, since these are liable to fluctuations which cannot be foreseen. Where these circumstances arise, the E.C.G. Department is again ready to assist manufacturers by insuring against advances in the rates beyond certa in limits. It is sounder estimating to calculate "delivered" charges on the basis of the insurable limits.

In cases where medium-term contracts were made pre-war on f.o.b. terms, their completion under present conditions may often prove more onerous to neutral debtors than was originally contemplated; part of the enhanced costs may be reduced if the manufacturer insures against war risk under the United Kingdom Government scheme rather than leave the debtor to cover as best he may in a restricted and unreliable local insurance market. Such a course, if followed, enhances the prestige of the United Kingdom as a manufacturing country.

Finally, experience proves it necessary to sound a warning in regard to the loose employment of the term "banker's credit." A credit opened by a foreign bank, however high its standing, does not avoid the transfer risk unless it bears the confirmation of a first-class British bank. The provision of such a confirmation involves the foreign client in additional expense which he seeks to avoid wherever he can; consequently, it becomes important to clause contracts financed by credits in specific terms, and misunderstanding is only avoided if it is made clear that the manufacturers require "an irrevocable credit established in our favour by, or confirmed by, a London banking house acceptable to us."

In the future, as in the recent past and present, conditions in capital markets are hardly likely to conduce to long-term financing by capitalisation of mining, electrical generation, irrigation, harbour construction, radio diffusion, and similar projects. It may prove that during the war the Dominions and Colonies may build up balances in London, and so reduce even further the remote transfer risk which exists in their case; such funds will be available for credits and progress payments. In the case of foreign neutral countries, not only is the London capital market unapproachable, but the medium-term is fraught with such dangers as to put manufacturers on inquiry as to the greatest possible measures of risk avoidance they can achieve by the various means I have briefly examined.

Surface Hardening by Induction*

By H. B. OSBORN, Jun.

Introduction

ONE of the recent outstanding developments in the heat treating field has been the application of induction heating to localised surface hardening. The advances made contingent with the application of high-frequency current have been nothing short of phenomenal. Starting a comparatively short time ago as a long sought after method of hardening bearing surfaces on crankshafts (several million of these are in use, setting all-time service records), to-day finds this very selective surface hardening method producing hardened areas on a multiplicity of parts. Yet, in spite of its present-day breadth of application, induction hardening is still in the infant stage. Its probable utilisation for the heat treating and hardening of metals, heating for forging and brazing or soldering of similar and dissimilar metals is unpredictable.

Induction hardening results in the production of locally hardened steel objects with the desired magnitude and depth of hardness, essential metallurgical structure of core, demarcation zone and hardened case, with a practical lack of distortion and no scale formation. It permits equipment design which warrants mechanisation of the whole operation to fulfil production line requirements. Time cycles of only a few seconds are maintained by automatic regulation of power and split second heating and quenching intervals indispensable to the creation of facsimile results of exacting specifications. Induction hardening equipment permits the user to surface harden only the requisite portion of almost any steel object and thus maintain the original ductility and strength; to harden articles of intricate design which cannot be feasibly treated in any other way; to eliminate usual expensive pre-treatment, such as copper plating and carburising and costly subsequent straightening and cleaning operations; to cut down on material cost by having a wide selection of steels from which to choose; and to harden a fully machined item without the necessity of any finishing operation.

Even with the most cursory glance at the case records one observes the breadth of use of induction hardening as well as its application to the hardening of items which heretofore had been considered impossible to treat, and to the performance of a number of extraordinary operations. In every instance will be found an inherent increase in quality, a decrease in cost, or both.

Electric Induction as Applied to Surface Heating

To the casual observer it would appear that induction hardening is possible as a result of some energy transformation occurring within an inductive region

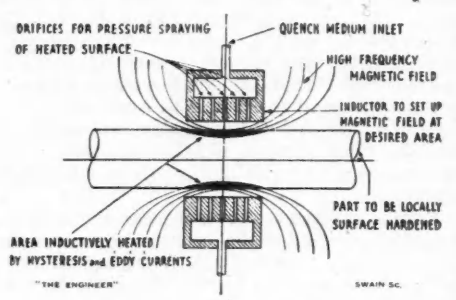
ORIFICES FOR PRESSURE SPRAYING OF HEATED SURFACE
QUENCH MEDIUM INLET
HIGH FREQUENCY MAGNETIC FIELD
INDUCTOR TO SET UP MAGNETIC FIELD AT DESIRED AREA
PART TO BE LOCALLY SURFACE HARDENED
AREA INDUCTIVELY HEATED BY HYSTERESIS and EDDY CURRENTS
"THE ENGINEER"
SWAIN SC.

FIG. 1—*Schematic Diagram of an Inductor Block and Magnetic Field while Heating a Bar*

of copper. The copper carries an electric current of high frequency and within an interval of a few seconds the surface of a piece of steel placed within this energised region is heated to its critical range and is then instantly quenched to optimum hardness. Fig. 1 demonstrates the essential details. To the manufacturer of equipment for this method of hardening it means the application of the phenomena of hysteresis, eddy currents and skin effect to the effective production of localised surface hardening.

The heating is accomplished by the use of high-frequency currents. Specifically chosen frequencies from 2000 to 10,000 cycles and upward of 100,000 cycles are being used extensively at the present time. Current of this nature, when caused to flow through an inductor, will produce a high-frequency magnetic field within the region of the inductor. When a magnetic material such as steel is placed within this field there is a dissipation of energy in the steel which produces heat. The molecules within the steel attempt to align themselves with the polarity of the field and with this changing thousands of times per second an enormous amount of internal molecular friction is developed as a result of the natural tendency for the steel to resist the changes. In this manner the electric energy is transformed, through the medium of friction, into heat. However, since another inherent characteristic phenomenon of high-frequency current is to concentrate on the surface of its conductor, only the surface layers become heated. This phenomenon, called skin effect, is a function of the frequency and, other things being equal, higher frequencies are effective at shallower depths. The frictional action producing the heat is called hysteresis and is obviously dependent upon the magnetic qualities of the steel. Thus, when the temperature has passed the critical point at which the steel becomes non-magnetic, all hysteretic heat ceases. There is an additional source of heat due to eddy currents which occur as a result of the flux changes and large currents much the same as eddy swirls in a rapidly moving stream of water. With the resistance of the steel increasing with increase in temperature the intensity of the eddy current effect is decreased as the steel becomes heated and is only a fraction of its "cold" original value when the proper quenching temperature is reached.

When the temperature of an inductively heated steel bar arrives at the critical, all heating due to hysteresis ceases and that due to eddy currents continues at a greatly reduced rate. Since the entire action goes on in the surface layers, only that portion is affected. The original core properties are maintained with the surface hardening accomplished by quenching when complete carbide solution has been attained in the surface areas. Continued application of power causes an increase in depth of hardening, for as each layer of steel is brought to temperature the current density shifts to the layer beneath, which offers a lower resistance.

It will at once be obvious that the selection of the

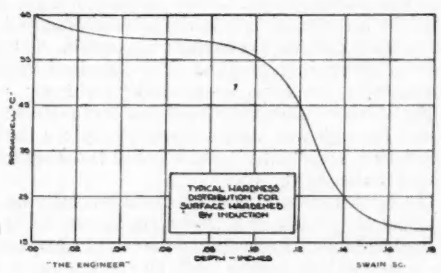

FIG. 2—*Typical Hardness Distribution*

proper frequency and control of power and heating time will make possible the fulfilment of any desired specifications of surface hardening.

Metallurgy

The unusual behaviour of steel when heated by induction and the results obtained merit a discussion of the metallurgy involved. Carbide solution rates of less than a second, higher hardness than is produced by furnace treatment, and a nodular type of martensite are points of consideration that classify the metallurgy of induction hardening as "different." Further, surface decarburisation and appreciable grain growth do not occur because of the short heating cycle.

Induction hardening produces a hardness which is maintained through 80 per cent. of its depth, and from there on toward the core, a gradual decrease through a transition zone to the original hardness of the steel as found in the core which has not been affected. The bond is thus ideal, eliminating any chance of spalling or checking. The curve of Fig. 2 is representative of the hardness distribution. The gradual transition from the martensite of the hardened zone through the pearlitic martensitic demarcation area to the pearlite of the core is at once obvious.

Present-day metallurgists agree that complete carbon solution can be accomplished in a relatively short time. Recent research data demonstrate the solution rate to be of the order of several seconds. Induction hardening further indicates that under proper conditions less than one second is required for complete transformation to the austenitic condition, as evidenced by maximum hardness and the absence of carbides in the hardened zone of such steels as S.A.E. 1050, &c. The prior treatment of the steel must of necessity be of such a nature as to produce desirable structure. The foregoing conclusion on carbide solution rates is based on the fact that a total heating time of two to three seconds produces temperatures in excess of the critical for only a fraction of that time. Data are available, however, where maximum hardness has been attained with a total heating time of 0·6 sec., of which 0·2 sec. was the time above the lower critical.

In view of the extremely rapid transformation of pearlite to austenite accomplished by induction heating and the tendency for this to occur between the lower and upper critical, a considerable amount of free ferrite might be anticipated. This, however, is not the case unless the heating is stopped at the instant diffusion has been completed within the ferrite boundaries. There is a preferential removal of carbides over ferrite and a major portion of the ferrite persists until most of the carbides have become diffused. The next step in this rapid diffusional process involves the removal of free ferrite and the formation of a fine homogeneous structure which is retained in quenching.

In the attainment of maximum hardness it seems reasonable to assume that complete carbide solution and thorough homogeneity has been achieved. Not only must the temperature be sufficient to allow this diffusion to begin, but the time must also lend itself to the fulfilment of completeness. Low-carbon areas and grain boundaries must have been eliminated as well as any original free ferrite. Heating by means of an induced high-frequency current apparently has a stimulating effect on carbide solution and the production of a homogeneous austenitic condition. Not only is the time requirement cut down, but a further refinement occurs which has the ultimate result of higher hardness than is obtainable on an identical piece which has been furnace heated and quenched to the maximum hardness of furnace hardening.

Carbide Diffusion

A series of tests was undertaken to study the rate at which carbide solution takes place during the heating of steel by electrical induction. An S.A.E. 1050 fine-grained (6 to 8 McQuaid-Ehn) steel was used having the following analysis:—

	Per cent.
Carbon	0·501
Manganese	0·890
Phosphorus	0·016
Sulphur	0·026
Chromium	0·290

Test bars, 1in. (25 mm.) in diameter and 5in. (127 mm.) long, were turned from quartered 2·25in. (57 mm.) diameter round stock, and the central 2in. (51 mm.) of the 5in. length turned to an oversize ¼in. (13 mm.) diameter with ⅜in. (16 mm.) fillet. After hardening the small diameters, they were ground to 0·505in. (12·8 mm.) for tensile tests, so that physical tests could be run if desired. This diameter was selected for very specific reasons. It was large enough to give positive results and show variations not always noticeable in extremely small pieces. At the frequency employed there would be no tendency to have the heat localised in the surface areas. Further, this diameter is well within the "critical size" and may be effectively centre quenched. Thus in most cases the entire radius was produced as a transition zone, there being a differential of hardness and structure from the surface to the centre of the bar.

The inductor used was a split block, 1·75in. (44·5 mm.) wide and with a ⅝in. (16 mm.) hole. Each piece was hardened at 2000 cycles and with a controlled power input to the experimental equipment. With power input "A" taken as 100 per cent., "B" represents 150 per cent., "C" 200 per cent., and "D" 250 per cent. An accurate timing mechanism was used and quenching by jets through orifices in the inductor was performed the instant the power was turned off, the entire cycle being automatically controlled. Quenching continued long enough to bring the test bar to approximately 100 deg. Fah.

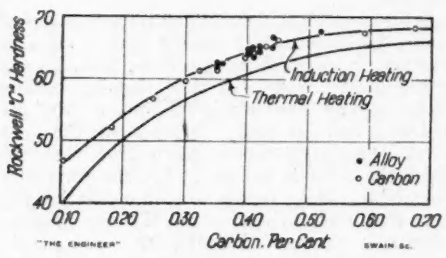

FIG. 3—*Maximum Hardness Obtainable for Varying Carbon Content in Steels*

(38 deg. Cent.). Drawing at 210 deg. Fah. (99 deg. Cent.) for one hour followed in order to relieve strains.

Each sample was cut through the centre of the hardened areas after hardness readings had been taken on the circumference at that location. The additional Rockwell readings were made on the polished cut face on circles circumscribed at 1·5 mm., 3·0 mm., and 5·0 mm. from the outer edge and on the centre area. Table I gives all pertinent data.

Calculations of the length of time the surface of many of the test bars were actually above the lower critical yield extremely small values. Such values are in many instances less than 1·0 sec. with specimens No. 6, 13, 20 and 30 being of the order of 0·2 sec. to 0·3 sec. Complete carbide solution and homogeneity has been accomplished in each, as evidenced by satisfactory hardness and lack of free ferrite and carbide in the microstructure. The steel used for the tests described was slightly sorbitic, but comparison with the solution rate possibly in a completely pearlitic structure demonstrates that carbide solution in a few tenths of a second is really not phenomenal.

Super-hardness

In order to demonstrate the increased or super-hardness obtainable with induction heating a number of steels with carbon content ranging from 0·10 to 0·70 per cent. were tested. Samples were received from three different sources in sizes from 0·5in. to 1·5in. (13–38 mm.). All were fine-grained (6–8 McQuaid-Ehn) and either normalised or quenched and drawn. Twelve carbon steels and twelve alloy

* The Electrochemical Society, Cleveland, U.S.A., April 16th, 1941.

steels made up the samples tested. Each sample was placed in a commercial inductor block and asembly and heated to approximately 50 deg. Fah. (10 deg. Cent.) above the Ac_3 and instantly quenched. The water pressure was 85 lb. per square inch at the inlet valve, but due to loose coupling between the steel and the inductor the pressure on the surface of the test specimen was only a small fraction of that amount. However, this clearance permitted the use of a large quantity of water, which made possible a rather drastic quench. No attempt was made to ascertain whether or not the critical cooling rates had been

TABLE I.—*Hardness Tests on Treated ½in. (13 mm.) diameter Bar*

Specimen number.	Power input.	Time sec.	Rockwell "C."		Millimetres from edge.*		Centre
			0·0.	1·5.	3·0.	5·0.	
1	A	11·8	65·8	64·2	64·1	64·1	64·1
2	A	9·5	65·4	63·8	63·8	63·8	63·9
3	A	8·3	65·5	63·8	63·9	63·9	63·9
4	A	4·6	65·5	64·8	64·3	64·0	63·7
5	A	4·2	65·4	64·8	64·3	63·6	63·1
6	A	3·7	65·3	64·2	62·8	54·6	48·0
9	B	8·2	66·2	64·6	64·5	64·6	64·6
10	B	6·8	65·9	64·2	64·2	64·1	64·0
11	B	4·4	65·8	65·0	64·6	64·3	64·2
12	B	3·3	65·9	65·0	64·0	63·2	62·8
13	B	2·1	66·0	63·1	57·3	34·1	29·1
16	C	6·0	66·0	64·2	64·1	64·2	64·3
17	C	4·7	65·6	64·2	64·3	64·2	64·2
18	C	3·3	65·9	65·0	64·7	64·3	64·0
19	C	1·9	65·8	64·1	62·6	38·4	33·1
20	C	1·3	65·4	54·7	38·9	30·1	26·3
23	C	1·1	32·2	29·9	26·7	24·0	21·0
24	D	2·9	65·3	64·5	64·6	64·5	64·5
25	D	2·9	65·3	64·5	64·5	64·5	64·4
26	D	3·0	65·7	64·7	64·6	64·6	64·6
27	D	1·8	65·2	64·7	63·8	62·1	60·5
30	D	0·6	65·3	51·5	37·0	26·3	16·7

* Average of readings taken on circles spaced at distances indicated.

	Per cent.
0·0 mm.—30 readings	A—100
1·5 mm.—25 readings	B—150
3·0 mm.—18 readings	C—200
5·0 mm.— 8 readings	D—250
Centre—5 readings	—

exceeded, but the hardness results indicate that this must have been the case. Further, these results preclude the presence of any appreciable amount of retained austenite. Surface readings were taken with

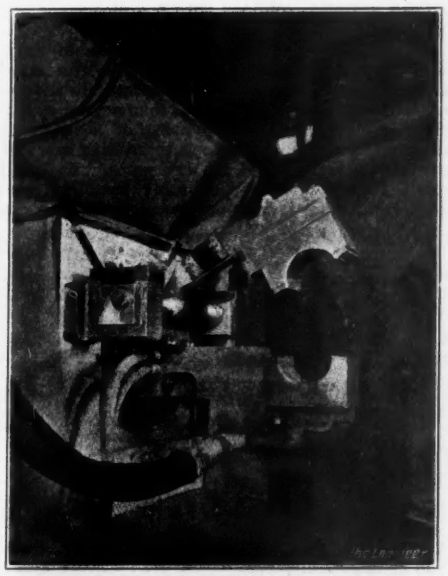

FIG. 4—*Typical Inductor Block*

a Rockwell hardness tester and averaged from thirteen to fifteen readings for each sample. The average hardness values have been plotted in Fig. 3, giving the curve which is designated "Induction Heating."

Higher maximum hardnesses result when steel is heated inductively than when heated thermally. This hardness increment is around 2 to 3 points Rockwell "C" at high per cent. carbon and 5 to 6 points Rockwell "C" at low per cent. carbon. The data indicated by the thermal heating curve are from purely experimental research methods and equipment and are not representative of actual production practice results. The values shown by the "Induction Heating" curve are reproducible in an induction hardening unit operating on a production schedule.

It would be unreasonable to assume that the maximum values representing thermal heating are lower than those shown for induction heating because of a less drastic quench. A logical consideration of the procedure followed would seem to admit of a cooling rate which was in excess of the critical cooling rate. Explanation must therefore be found in some structural difference which is present at the time of quench. The fine nodular and more homogeneous martensite which results from induction hardening is more readily apparent with carbon steels than with alloy steels because of the nodular appearance of most alloy martensite. This fine structure must have for its origin an austenite which is the result of a more thorough carbide diffusion than is obtained with thermal heating. Practically instantaneous development of critical temperatures throughout the entire microstructure of the alpha iron and iron carbide is particularly conducive to rapid carbide solution and a distribution of constituents which has as its inevitable product a thoroughly homogeneous austenite. Further, the conversion of this structure to martensite will produce a martensite which possesses similar characteristics and a corresponding resistance to wear or penetrating instruments.

We have examined short-time cycle induction-hardened specimens which, at a very high magnification, show a lamellar structure in the martensitic areas. The following explanation is offered for consideration :—

Carbide solution may take place evenly from the adjacent surfaces of two carbide lamellæ and progress only far enough so that a microscopic examination of this crystal would not show the decrease in thickness of these lamellæ which has taken place. Thus a

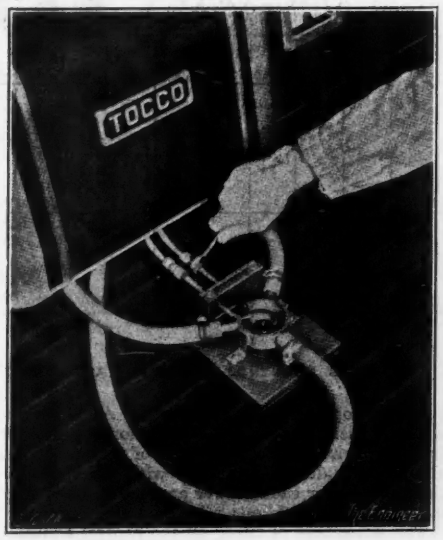

FIG. 5—*Typical Multi-turn Coil*

portion of the ferrite becomes converted into austenite. The intervening region may be very low in carbon, but being surrounded by the other structures of higher hardness, particularly the carbide lamellæ, any hardness penetrator would indicate a value which will be an average of the high hardness and lower hardness of adjacent areas. This would not be detectable by the various etching technics which we have employed. No such condition can exist when a piece is inductively hardened from the proper prior structure or when heating cycles of several seconds are used.

EQUIPMENT

All surface hardening equipment consists of an inductor, quenching auxiliaries, suitable transformers and capacitors, automatic timing controls, and a high-frequency generator. In addition, provisions are made for handling of the parts intermittently or continuously depending upon production requirements.

The inductor may be a single turn of copper to fit the piece to be hardened or several turns of copper tubing shaped for the same purpose. Careful design is essential at this point to ensure maximum efficiency. However, symmetrical inductors may be used to surface harden unsymmetrical objects because of the natural tendency of the high-frequency current to follow the contour of the piece. The quenching medium is supplied through the inductor by means of orifices which are an integral part of it. Figs. 4 and 5 show two such inductors which are representative. The same timing device which controls the heating cycle operates an electric quench valve and controls the quenching cycle to the same degree of accuracy.

Automatic control and accuracy are keynotes in induction hardening from two standpoints. First, it is merely a matter of equipment design to have such precision involving exact locations of hardened areas (more than one area can be treated simultaneously), and automatic control to within 0·1 sec.; secondly, this control makes each hardening operation and hardened object a facsimile of all those before and after it. Further, total elimination of the human error avoids the usual variations and mistakes so characteristic of manual control.

Large converters of the generator type are in everyday use for 2000, 3000, and 10,000 cycles at capacities up to 1000 kW. Smaller 7·5 kW to 30 kW units of the spark gap oscillator type are used at frequencies upwards of 100,000 cycles. Extremely high frequencies at low power are available from tube oscillators, but not much of commercial importance has been done with such units for heat treating or hardening.

The high-frequency current is usually generated at high voltage ranging from 200 to 1000 volts, depending upon the particular unit. It is then transformed and fed into the inductor. The transformer is designed for the specific frequency and the inductors to be used with it. In some instances, where a multi-turn coil is employed, the transformer is eliminated, and connection made directly across the generating source.

In order to obtain high efficiency, the high-frequency power factor is adjusted and maintained as near unity as possible. This is accomplished by connecting in the circuit the proper amount of capacitance. Variations in capacitor requirements are readily accommodated by a switch mechanism which provides immediate change of the number of condenser units.

The power used for each hardening operation is controlled and maintained by the field excitation of the generator. Occasionally, it is found that a fixed excitation will not produce a constant power output due to the electrical characteristics of the steel changing during the rising temperature. A longer, undesirable heating cycle would result. However, the power is maintained constant by an automatic control system which changes the external resistance of the field circuit at pre-set, split-second type intervals while the power is on.

One of the most recent developments in high-frequency generating equipment is a small compact single unit 3600 r.p.m. generator set, producing 10,000 cycle current at 220 and 440 volts up to 100 kW output. These are induction motor-driven units and are available at 10 kW, 20 kW, 40 kW, 60 kW, 80 kW, and 100 kW. Fig 6 shows hardening

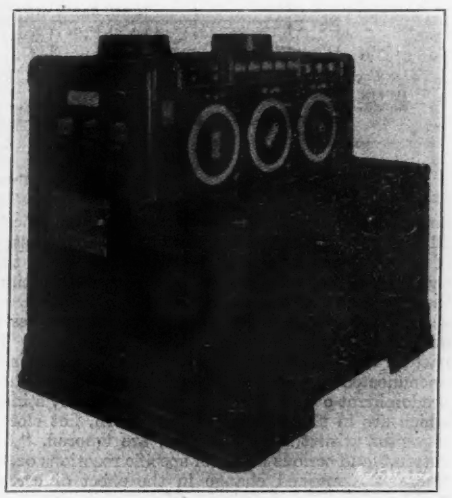

FIG. 6—10,000-*Cycle Induction Hardening Unit ; Three-station Operation*

equipment which is a standard design and which incorporates any one of the different motor generators. Inductor blocks mount on the transformer connections and may be used in a vertical, horizontal, or any intermediate plane. The timing units which control the split-second heating and quenching cycle are quickly adjustable for each specific part to be treated and complete change from one job to another, including change of inductor block, quench lines and fixtures, is a matter of but a few minutes.

Fatigue Following Highly Skilled Work

THE Ferrier Lecture was delivered at the Royal Society on Thursday, May 29th, by Professor F. C. Bartlett. The subject was "Fatigue Following Highly Skilled Work."

The author's summary runs as follows :—If the character and causation of fatigue following highly skilled work are to be understood the first need is for the discovery of more relevant and experimentally controlled facts. Unfortunately, almost all the investigators who have attempted to study fatigue of this type have adopted methods taken over with very slight change from those which have proved valuable in the study of simple muscular fatigue. They have chosen elementary operations usually considered to require some "mental" effort, such as easy calculations, word or colour recognition and naming, and the like ; have repeated these operations over and over again for long periods and have tried to express the resulting fatigue in terms of the diminution in quantity and quality of the work done. The skill fatigue of daily life is not set up under such conditions. Routine repetition of simple actions is not a characteristic of any highly skilled work, and least of all of work having a strong "mental" component. The operations involved here are marked by complex, co-ordinated and accurately timed activities. The stimuli in response to which these activities are set up are neither simple nor do they usually fall into an order of fixed succession. They have the character of

a field, or a pattern, which has become very highly organised and may retain its identity in spite of a great diversity of internal arrangement.

It is possible to develop fully controlled experimental situations in which these realistic considerations have full play. When this is done the picture of fatigue following highly skilled work which emerges has certain strongly marked characters.

In such fatigue the "standards" accepted and followed by the central nervous system unwittingly deteriorate. The operator tends to think that he is doing better work, because errors treated as significant all the time get wider and wider limits. Until a stage of great fatigue is reached it is far more likely that the right actions will be performed at the wrong times than that the wrong actions will be performed. If accurate timing is insisted upon, gross mistakes of action may appear. The stimulus field splits up. Its pattern character alters. It becomes a collection of unconnected signals for action, with some of these predominant over all the others. Particularly stimuli which are in the margin of the pattern, not closely organised with the central field, are ignored, "forgotten," and serious lapses of specific reactions occur. There is a marked change in the effect of certain "distracting" or additional stimuli. Sensations of bodily origin, in particular, become more pressing and insistent and affect the performance in ways peculiar to the tired operator. Side by side with all these changes go constant subjective symptoms. Verbal reports about any circumstances connected with known failure of performance become increasingly inaccurate, and errors are regularly projected upon objective conditions or attributed to the interference of other people. There is a tremendous growth of irritability.

An attempt is made to discuss the light thrown by this picture upon the relation of high-level central nervous functions to simpler neuro-muscular mechanisms.

Automatic Electrically Controlled Soot Blowers

AUTOMATIC soot blowing possesses recognised advantages over the manual system and in maintaining a strictly controlled sequence of operations, and is said to enable boilers to be steamed for longer periods at considerably increased efficiency before the periodic overhaul becomes necessary. Each blower comes into action in the correct sequence, at the correct rate and for a predetermined period, so as to clean the boiler heating surfaces with the minimum loss of steam. Incorporated in the patented automatic soot blowing system developed by Hopkinsons, Limited, of Huddersfield, are an arrangement for operation of the master steam valve, time control of the drainage system for the piping, and automatic operation of the blowers. A cubicle, suitable for placing on the firing floor, houses the control equipment, an important feature of this unit being a mimic boiler diagram together with the appropriate signal lamps for each blower arranged on the face of the cubicle—Fig. 3.

The advantage of siting all the control equipment in the cubicle, instead of in the dusty, hot atmosphere liable to occur near the soot blowers, is obvious. At the same time, the attendant is able to check over the operation of the scheme at a glance and can ascertain which soot blower is in action at any given moment. If, for any unforeseen cause, a blower should fail to operate or should take longer than the predetermined time for operation, this fact is duly indicated at the cubicle by audible and visible alarms. A special isolating switch completely isolates the blower head in question and allows the necessary maintenance work to be commenced upon it while the remainder of the soot blowing system continues to operate. A continuous light on the cubicle indicates any blower head thus isolated.

When the "open" button is pressed to operate the soot blower master steam valve the latter opens slowly, gradually admitting steam to the piping. A period is allowed to elapse, controlled by a time switch, before any of the blowers can be brought into action and ensures that the piping system shall be thoroughly warmed up, any condensate being drained by steam traps. On the completion of this process the time delay switch sets in motion a rotary sequence switch in the cubicle. This switch permits the operation of blowers to be arranged in any desired sequence and for each individual blower to operate a number of times if found necessary. As soon as the operation of the blowers is completed the master valve is closed and the rotary sequence switch comes to rest ready for commencing its sequence operation as and when required—Fig. 2.

An objection to a cascade system in which the ending of the operation of one blower starts up the next, is that, under those conditions, considerable time is lost during which no steam is being blown into the boiler furnace. In the Hopkinson system of electrically controlled soot blowing arrangements are made for the idle time of any blower (such as the retractable type) to overlap with the blowing time of any other blower, and the objection is thus overcome.

A hand wheel projecting through the front of the cubicle and provided with a clutch enables the sequence switch to be rotated by hand in the event of failure of the rotary sequence switch motor; alternatively the master valve and each soot b ower can be independently operated from the separate push-button stations provided. As a precaution against any possible interruption of the electric current, blowers are also equipped with the means for hand operation.

Three types of electrically operated soot blowers are standardised by the manufacturers. The single-nozzle retractable type is usually located in the combustion chamber, where the gas temperature exceeds 1900 deg. Fah., the nozzle being of heat-resisting alloy steel and retractable so as to be withdrawn well outside the influence of the hot gases. The multi-nozzle rotary type is preferably installed where temperatures are lowest and where multi-tube nests have to be cleaned. For units required to experience high temperatures the elements are specially treated to resist oxidation and corrosion, or supplied in solid-drawn heat-resisting steel tube. A flexible coupling between the blower and the element obviates much of the load and stress, due to distortion and misalignment of the element, being transmitted to the blower mechanism. The single-nozzle rotary type is similar in design to the multi-nozzle unit, a single nozzle being substituted for the multi-nozzle element and is located where the gas temperatures are below 1900 deg. Fah., usually in the bent tube sections of the boiler and where space is available for efficient operation. A typical electrically operated soot blower is illustrated in Fig. 1.

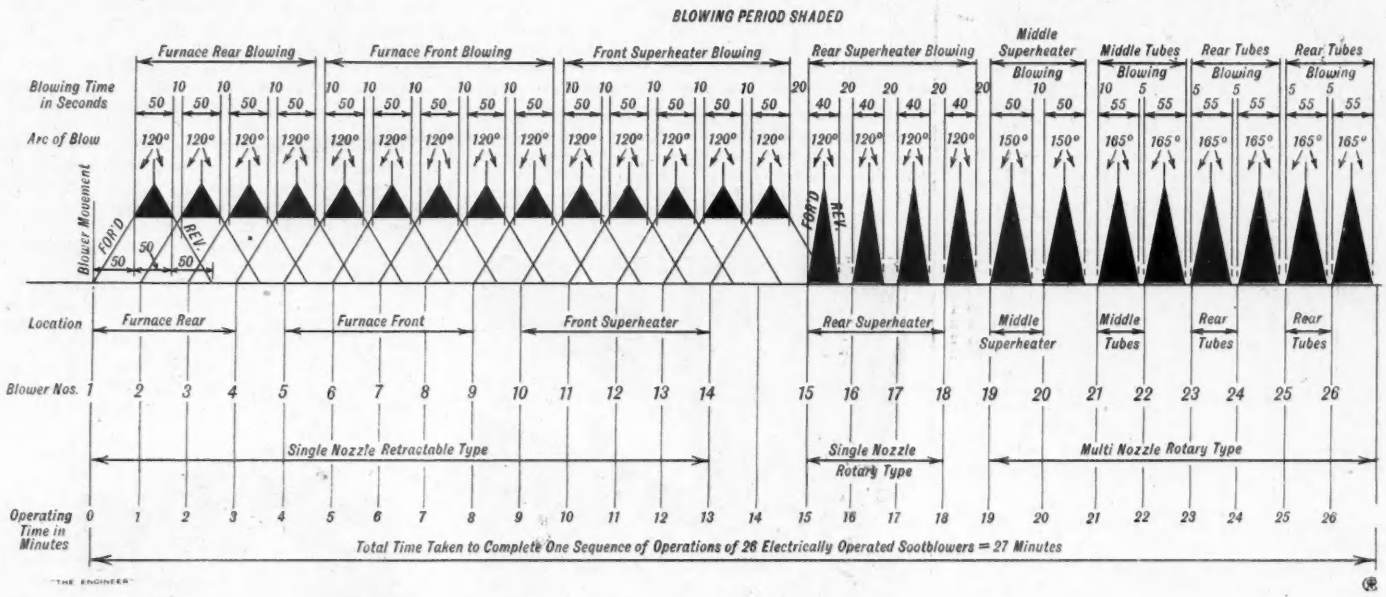

FIG. 2—TYPICAL OPERATING SEQUENCE CHART OF AUTOMATIC SOOT BLOWERS

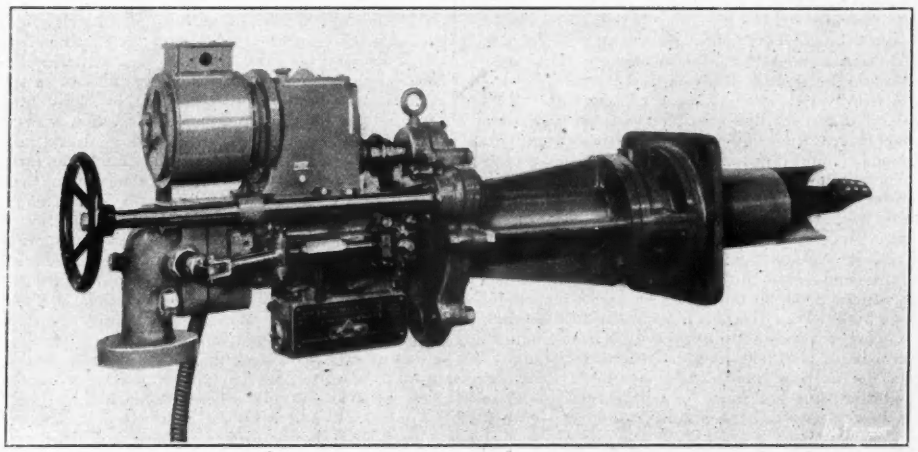

FIG. 1—ELECTRICALLY-OPERATED SOOT BLOWER

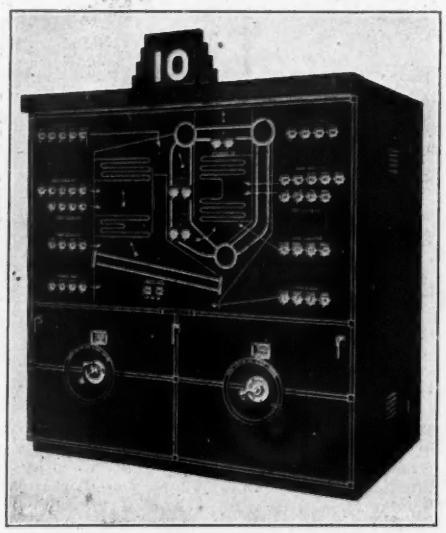

FIG. 3—CONTROL EQUIPMENT CUBICLE

The Rebuilding of Bombed Property

IN the House of Commons on Thursday, May 1st, the Parliamentary Secretary to the Ministry of Works and Buildings was asked in what circumstances, and subject to what limitations, business premises are allowed facilities for immediate reconstruction after damage by enemy action; what is the position of private houses or other domestic premises so damaged; and whether and why any priority is given in relation to larger business premises as against the need of those whose homes have been affected. In reply, Mr. Hicks said that he was very glad to take the opportunity of making clear to the House the conditions that now governed air raid damage repairs. The Government had given an absolute priority over all other work to first-aid repair work for essential public services, war factories, and houses. In the case of households where the owner was unable or was unwilling to carry out the work himself, the responsibility rested on the Local Authority. Where the owner himself put the repair work in hand he would require a licence if the work was of the nature of reconstruction and costed £100 or more. The owners of shops, offices, banks, warehouses, and other industrial and commercial buildings, including factories not engaged to an important degree on war production, must apply for a licence if the work of reconstruction was to cost more than £100. Applications were referred to the Board of Trade, which recommended that licence be granted only if it considered that the work was urgently necessary in the public interest. Factories engaged on war production were dealt with by licence or otherwise in consultation with the appropriate Government Department. Until recently there had been no attempt to license reconstruction of air raid damage repair in cases in which the cost was below £500. But a new Order had just been issued, and he emphasised that all such reconstruction costing £100 or over required a licence or an authorisation, and it was intended to enforce that. No priority, it would be seen, Mr. Hicks said, was therefore given to larger business premises as against the needs of damaged homes.

BOOKS OF REFERENCE

The Directory of Shipowners, Shipbuilders, and Marine Engineers, 1941. The Directory Publishing Company, Ltd., 33, Tothill Street, S.W.1. Price 20s. net.—We are pleased to record the appearance of this, the thirty-ninth edition of the Directory, which has been compiled under the direction of Mr. John P. Taylor, the editor of the *Shipbuilding and Shipping Record*, and has been successfully revised, despite the considerable difficulties imposed by censorship conditions and the lack of access to enemy-occupied countries. In deference to the decision of the Government not to publish the losses of individual ships, the fleets of the British and Allied firms remain substantially as in the last edition, the same applying with one or two exceptions to the fleets of shipping companies in enemy or occupied territories. The new edition records changes in the personnel of many companies, and new information is given regarding the fleets and companies in non-belligerent countries. A further feature is the inclusion in the official section of the shipping and trade commissions which have been established in this country by Belgium, Holland, Free France, Greece, Poland, and Norway. In other respects the general arrangement of the Directory remains on the basis established some years ago, which fills the demand for a standard book of reference on shipping and shipbuilding matters.

Mining Year Book, 1941. London: Walter E. Skinner. Price 20s.—The fifty-fifth edition of this book, which appears regularly in February each year, comprises 860 pages, and contains full particulars of all the world's principal mining companies, numbering 975, arranged in alphabetical order (South African, Rhodesian, West African, Australasian, Canadian, American, and other countries), together with lists of directors (2965) and mining engineers, mine managers, &c. (1035), with their addresses and the companies with which they are associated. Despite the delays and interruptions of the mail services and other abnormal conditions met with during compilation, it is claimed that details of the results of most of the companies included in the book will be found as up to date as customary.

The Blue Book, 1941. London: Benn Brothers, Ltd. Price 25s.—Although paper rationing has made it necessary to print the Blue Book—the Electrical and Engineering Trades Directory—upon thinner material, the substance of the work remains what it has been for fifty-nine years. Here may be found the names and addresses of firms, persons, and organisations in the electrical and allied engineering industries. As usual, the contents are separated and classified by numerous thumb tags. For many years the Blue Book has been indispensable to us, and we rejoice that the war has not arrested its publication or materially changed its appearance.

Electrical Year Book, 1941. Manchester: Emmott and Co., Ltd. Price 2s.—In this, the thirty-fourth issue, several new items have been added to the "Electrical Year Book," whilst a general revision has taken place. Amongst the new matter may be mentioned a page entitled "Superimposed Control," in which the employment of a high-frequency ripple superimposed on the normal sinusoidal A.C. supply for the control of remote relays is described; some notes on air-cooled, steel-clad, pumpless rectifiers; and the localisation of cable faults. The testing section of the pocket book has been overhauled, largely rewritten, and new matter added.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

The Scrap Position

The chief topic of interest at the moment is that of supplies of scrap iron and steel. Questions have been asked in Parliament recently as to whether these are adequate and reassuring answers have been given by Government spokesmen. On the other hand, observers in the chief iron and steel centres have frequently commented on the shortage of various descriptions of scrap, particularly good heavy melting steel scrap and mixed iron and steel, and also good heavy foundry cast iron and machinery metal in furnace sizes. One reason may have been labour shortage, which has restricted the supply of furnace size material to the works. Imports of foreign scrap appear to have been reduced so that this country is becoming more dependent on domestic material. Mr. George Wood, Director of Scrap Supplies at the Iron and Steel Control, has declared that the stocks of scrap iron and steel at the furnaces, ready for conversion into steel for war needs, are at least 50 per cent. greater than they were twelve months ago. Scrap is being salvaged from every possible source, and public scrap dumps are being drawn upon as quickly as possible. Urging everybody to continue their efforts to maintain the supply of scrap, the Director of Scrap Supplies has pointed out that the material collected may not be wanted for immediate use, since in immense wartime operations long views must be taken and provision for supplies made months ahead. It should not therefore be assumed that the situation is not fully in hand because collected stocks are not in evidence at various points up and down the country. Mr. Wood did not entirely deny that consumers are not getting as much scrap as they would like, but here again he insisted that a long view must be taken as nobody knew what the future held, so that careful planning and considered economy was essential to ensure that Britain's reserves of scrap were used, together with other materials needed in the manufacture of steel, to the best advantage. Now that the United States is committed to still more active support for the Democracies, it is interesting to note that it is estimated in Washington that the United States steel production this year will be 1,400,000 tons short of requirements and 6,000,000 tons short next year, despite the fact that the industry is at present operating at full capacity and that considerable plant extensions are in progress. There is no doubt that in the near future steps will be taken to curtail non-essential civilian consumption of steel.

The Pig Iron Market

Foundry pig iron is perhaps the least favoured section of the market at the present time, since makers of light castings have suffered since the war began from the poor demand for their products. Makers of these light castings would like to see their services employed more fully on Government work. However, the output of foundry iron has been cut down in recent years in various parts of the country, and this has averted any possibility of a plethora of supplies. Meanwhile the heavy castings makers, producing castings for machine tools, are busy and are steady buyers of foundry pig iron. The hematite position is being helped by the allocation of imported material by the Control, and similar action is being taken in the case of low-phosphorus irons. In both cases home production is inadequate to meet the huge demand. No lack of high-phosphoric forge iron is reported by puddled bar makers. Special refined irons are being used as a substitute for hematite in some cases and supplies of these seem comparatively plentiful. As regards basic iron there is an excellent output, but owing to the tightness in the scrap supply position buying pressure is intense and the furnaces would like to be in a position to increase their production still further. Coke prices look like advancing, and in this case it would not be surprising if a further advance took place in the official maximum prices of pig iron. Generally speaking, moderate reserves exist of home-produced pig irons, and even in the case of hematite stocks of imported material are held by the Control.

The Midlands and South Wales

In view of the activity in the engineering industry on Government account, the demand for large castings in the Midlands is likely to remain intense for a long time. Pig iron supplies generally are satisfactory and local supplies are being helped by allocations of imported material by the Control. On the other hand, this district is sending foundry pig iron to other areas where production is either non-existent or insufficient. The bar mills are well employed, although the demand is reported to be rather quiet for certain descriptions. Small rounds, squares and flats are in good request, with the mills well booked up. On the other hand, the inquiry for crown bars and strip is somewhat disappointing. A continued improvement is reported for structural steel, such as joists and channels, and the works making these are better booked than for some time past; nevertheless, consumers can still get pretty prompt delivery in many cases. Plates, however, are scarce as the demand is intense. Special steel is an active market, as this material is of vital importance to the war effort. Colliery steel is going freely into consumption. In South Wales the war demand for steel is heavy, with makers well booked. Ordinary civilian requirements are taking a second place. Priority orders are being met promptly as a result. Finished steel is under considerable buying pressure. The demand for billets is excellent, with home supplies assisted by imports. All the local output of hematite and basic pig iron is being consumed, whilst the sheet mills are very busy on the basis of their present steel supplies.

Copper and Tin

On every side the fact is evident that all but a small percentage of the current production of finished and semi-finished copper and brass products are ultimately required in connection with Government war needs. Nearly all consumers are working at a high rate and the aggregate consumption of copper here is almost certainly a record. Satisfactory supplies of the metal continue to be provided by the Control for essential purposes, but in other directions the quantities available are distinctly limited. So far the United States Government has not actually imposed priorities on copper, although this step is expected at any moment, and seems the more likely following President Roosevelt's speech and the subsequent indication that priorities on steel might be expected. The consumption of copper by manufacturers in the United States in April is reported as 126,000 short tons, with unfilled orders on hand of over 500,000 tons. The consumption figure of 126,000 tons appears low considering the big increases reported recently, but it is believed this figure relates only to the United States domestic production of copper, so that a substantial tonnage would need to be added on account of metal supplied from abroad by the Metals Reserve Company. Opinion seems divided in the United States as to whether the domestic output could be materially expanded by permitting a higher price for copper, and for the time being, at any rate, the Government does not seem inclined to depart from its policy of a stabilised price at 12 cents. . . . The easier tendency in the London tin market, commented upon in our last issue, has been even more pronounced during the past week. The absence of any prospect of export licences being granted for English tin either to the United States or other destinations has left dealers with little to go for, and as there has been some smelter selling in the open market prices have moved downwards. They are at the present time well below the American price level, which has changed little in the last week or two. Consumption here has not fluctuated much, the tin-plate trade continuing to operate at a satisfactory level of capacity, whilst other uses, such as bronze bearing metals, solder, &c., are absorbing a good tonnage. In the United States a fair activity has continued in evidence in the open market, where dealers and consumers are willing to pay much higher prices than that fixed for the accumulation of strategic reserves. The Navy Department placed a further order this week for about 130 tons, compared with the previous order for 250 tons. Some recent estimates put the American visible and invisible stocks of tin at the end of April as 96,000 tons, compared with less than 30,000 tons at the beginning of 1940. Large though this tonnage is, it is less than some recent estimates have indicated. A Government spokesman said a short time ago that there were eighteen months' supply of tin in the country. Possibly, however, this referred to an emergency basis, when consumption for non-essential purposes would undoubtedly be curtailed.

Lead and Spelter

The lead position here has not changed much in recent weeks. The most active sections of the consuming industries are those engaged on Government requirements, which range from cables and batteries down to solder, with limited quantities of lead pipes and sheets, paint, and other materials required for official building work. Ordinary industrial needs have been severely curtailed and are satisfied fairly freely by the Control, which has plenty of lead available to meet all current requirements. The American market has not presented any fresh features and it remains to be seen whether lead will be affected by any of the new measures that may arise in connection with the intensification of the American armament production. . . . The spelter situation is one of unrelieved tightness, in that the war effort is requiring all the available supplies of metal and other users are having to go without. In brass, rolled zinc and galvanised products industrial consumers are finding it increasingly difficult to get supplies; but since the full war needs are forthcoming as and when required, the situation from an emergency standpoint can be considered satisfactory. A short while ago there was some talk in Canada of starting up an electrolytic zinc refinery in the eastern part of the Dominion, but this project seems to have fallen into the background. From this it should not necessarily be inferred that no expansion of Canadian output is under way, although no details are being published as to what is being done.

Non-ferrous Metal Prices

The London Metal Exchange official statement for May again indicates a slight decline in the average quotations of tin of £2 5s. 2d. for cash and £3 7s. for three months, compared with the April average. The settlement average is £2 4s. 9d. below that for the previous month. The statement, which includes the official maximum prices for copper, lead and spelter, is as follows:—

Standard tin	Cash (mean)	£267 13 11 5/11
	Three months (mean) ...	£266 8 11 7/11
	Settlement	£267 14 3 1/11

The following prices for copper, lead and spelter are the maximum prices fixed by the Controller of Non-ferrous Metals:—

	£	s.	d.	
Standard copper				
Electrolytic copper ...	62	0	0	delivered buyers' premises
Electrolytic wire bars ...	62	0	0	,, ,, ,,
Best selected copper ...	60	10	0	,, ,, ,,
Lead, good soft pig ...	25	0	0	,, ,, ,,
(foreign)				(duty paid)
Spelter, G.O.B. (foreign)	25	15	0	delivered buyers' premises (duty paid)

CANADIAN STEEL.—The Canadian Bureau of Statistics has reported that during the first four months of this year 755,162 tons of steel ingots and castings were produced in the Dominion, compared with 617,616 tons during the corresponding months of 1940.

Notes and Memoranda

Rail and Road

C.P.R. EARNINGS.—The gross earnings of the Canadian Pacific Railway for April amounted to 16,654,790 dollars, an increase of 4,610,866 dollars over the same month last year.

L.N.E.R. SUBURBAN SERVICES.—A number of improvements in the suburban services of the London and North-Eastern Railway came into operation with the introduction of the new time table on June 3rd.

MEXICAN RAILWAY EXTENSION.—The extension has been authorised by the Mexican Government of the Fuentes Brotantes-Punta Penasco Railway from Punta Penasco to Santa Anna, a distance of approximately 155 miles. The line will connect Lower California and the State of Sonora.

CONNECTICUT ROAD SURVEY.—An exhaustive survey of the highways in the State of Connecticut—the first since 1893—has just been completed. About forty-four maps have been produced covering rural as well as city areas, and these will be used as a basis for the future planning of all road construction. A new section of the highway department is to be set up to keep this information up to date.

A SPARK ARRESTER.—What is known as the Anderson locomotive front end is regarded in the United States as a practical spark arrester. No fewer than 150 locomotives on the Chicago, Milwaukee, St. Paul and Pacific are fitted with this device, the manufacturing rights for which were acquired by the Locomotive Firebox Company, Chicago, about two years ago. Since then further improvements and developments have been made to adapt the new front end design to general use on railways throughout the States. Experience indicates that locomotives can be turned in an eight-hour period for superheater unit repairs when equipped with this type of front end.

U.S. FLYING AMBULANCE GIFT.—The employees of the Baltimore and Ohio Railroad, through the medium of British railwaymen, have presented a cheque for the purchase of an R.A.F. flying ambulance to be named after Lord Stamp, late chairman of the L.M.S. Railway. The cheque was formally handed over to the New York representative of British railways and the President of the British American Ambulance Corps by Mr. Willard, president of the Baltimore and Ohio Railroad, at an "Aid for Great Britain" concert recently held at Baltimore. It is proposed that the aircraft should bear the following inscription: "Gift of Baltimore and Ohio R.R. employees to the British Royal Air Force in memory of Lord Stamp, outstanding leader of British railwaymen."

SWEDISH RAILWAY ELECTRIFICATION.—Electric working over the Langsele-Mellansel section (57 miles) of the Swedish State Railways northern line to Boden began in September last, and it is understood that electric traction was introduced on the 74-mile Mellansel-Vännäs section in February of this year. It is hoped to complete conversion as far north as Boden, where the already electrified Lapland iron ore line is joined, by the middle of 1942. The *Railway Gazette* states that it will then be possible to travel from Trälleborg in the south, *viâ* Stockholm, to Narvik in the north, 1376 miles, entirely by electric train. The whole journey, except for the last 28 miles to Narvik, will be over the Swedish State Railways. The conversion cost for the 309 miles from Mellansel to Boden is estimated at 15,000,000 kr. The current year's budget includes a sum of 2,500,000 kr. for electric locomotives, and the expenditure of a further 5,000,000 kr. for electric locomotives is envisaged during the next few years.

AMERICAN RAILWAY EFFICIENCY.—New records in operating efficiency were attained by the American railways during 1940, according to reports recently issued for that year. The reports summarised the outstanding operating performance of the railways as follows:—(1) The average amount of freight carried per train was greater than ever before on record; (2) freight was transported over the rails at an average speed never surpassed and approximately 62 per cent. higher than twenty years ago; (3) freight train performance per hour was approximately twice as good as that of 1921; (4) freight locomotives attained a new high mark in average daily mileage; (5) utilisation obtained from freight cars was greater than ever before; (6) fuel efficiency in freight service was higher than ever before; (7) number of freight cars in need of repair was lowest on record. Freight locomotives in 1940 operated a daily average of 107·2 miles, which also was a new record. The average daily movement of all freight cars, which includes those being loaded and unloaded, was 38·7 miles in 1940, which also was a record, and net ton-miles per freight car per day were 661 ton-miles. The previous record was established in 1937 with an average of 625 ton-miles per day.

Air and Water

H.M. SUBMARINE "USK."—The Board of Admiralty has announced that H.M. submarine "Usk" is overdue and must be considered lost.

INDIAN NAMES FOR NEW AIR SQUADRONS.—The Air Ministry announces that six fighter squadrons of the Royal Air Force have now been named after various parts of India, following gifts of money to the Ministry of Aircraft Production for the purchase of aircraft.

UNITED STATES BOMBERS.—According to a message from *The Times* correspondent in New York, the Boeing and Douglas aircraft companies and the Lockheed company's subsidiary concern, the Vega Aeroplane Company, have arranged to pool certain of their facilities so as to increase substantially the production for the United States and Britain of "flying fortress" bombers. These long-range four-engined bombers, which until now have been assembled in only one plant, will, it is stated, be assembled in future in four plants—at Burbank and Long-beach in California, at Seattle, and at Wichita, Kansas. The Boeing company's Wichita plant will quadruple its present area.

BOEING FLYING-BOATS.—The first of three Boeing flying-boats which the British Government has purchased from Pan-American Airways for the maintenance of air communications has arrived on this side of the Atlantic, having been flown across by a British Airways crew.

THE MAAS TUNNEL.—A letter written in January by Mr. J. P. van Bruggen, chief engineer of the Rotterdam Tunnelworks, to *Engineering News-Record*, says that construction of the Maas Tunnel has not been delayed very much by war circumstances. The last of the nine river caissons was sunk in December of last year.

SWEDISH SHIPPING LOSSES.—According to official figures for Swedish shipping losses, which have recently been published in Stockholm, Sweden had, up to the beginning of April, lost eighty-six ships since the beginning of the war, totalling 284,762 tons. All the vessels included in the figures given had been torpedoed, mined, bombed, or destroyed by artillery fire. Among the losses were included seven fishing vessels, while the rest belonged to the merchant navy. For comparison, it is stated that in the corresponding months of the last war, sixty-four Swedish ships of a tonnage of 74,611 tons were sunk.

WATTS BAR LOCK.—The lock at Watts Bar dam, on the Tennessee River, midway between Knoxville and Chattanooga, was placed in temporary operation during March, just fifty-three weeks after the first concrete was placed for the structure. The lock chamber is 60ft. by 360ft., designed for a normal lift of 57ft. and a maximum lift of 70ft. The downstream gates are complete and in use, but the permanent upstream gates cannot be used until the dam is completed and the reservoir nearly filled. Temporary upstream gates have been installed below the permanent gates to withstand up to a 10ft. head and to permit navigation during completion of the dam. Watts Bar dam is expected to be finished towards the end of this year and will provide a 9ft. channel to Fort Loudoun dam, 72 miles upstream. The dam will be 97ft. high and 2965ft. long, with a reservoir area of 41,600 acres.

Miscellanea

WAR DAMAGED TELEPHONES.—The Postmaster-General announces that he will make no claim against telephone subscribers or private wire renters in respect of war damage to Post Office telephone or telegraph apparatus on their premises. Such apparatus, therefore, should not be insured under the War Damage Act, 1941.

THE LATE MR. W. C. KNIGHT.—Mr. W. C. Knight, who for forty-three years had been on the staff of Callender's Cable and Construction Company, Ltd., died recently after a sudden illness. He was intimately connected with colliery electrification, serving on appropriate C.M.A. and other committees, and had been in charge of Callender's colliery department at Sheffield since its inception.

WATER POWER IN SWEDEN.—The fuel difficulties experienced during the past year stimulated further exploitation of the water power resources of Sweden, says the *Anglo-Swedish Review*. A survey carried out by Kommerskollegium shows that potential power production has undergone a very considerable increase in the last two years, in 1939 amounting to 11 per cent. in comparison with 1938. A further rise took place in 1940, but it is noted that owing to stoppages in important industries—above all, the pulp industries in the north—the actual output of power in many cases has been substantially reduced. The utilised output of power in 1939 was 7870 million kilowatt-hours, while the productive capacity was 9048 million kilowatt-hours. For comparison it may be mentioned that the production of electric power in 1913 was 1449 million, and in 1920 2605 million kilowatt-hours.

CANADIAN PAINTS AND VARNISHES.—In its report on the paint and varnish industry in Canada for 1939, the Dominion Bureau of Statistics gives the number of plants operated by the industry as ninety-five, of which forty-seven were in Ontario, twenty-eight in Quebec, nine in British Columbia, five in Manitoba, and one each in Saskatchewan, Alberta, Nova Scotia and New Brunswick. According to the *Chemical Trades Journal*, the total number of employees in the industry was 3540, and the output had a selling value ex works of 25,855,000 dollars, the highest figure since 1929. Products made in 1939 included 4,629,531 gallons of ready-mixed paints, 1,505,990 gallons of enamels, 2,300,139 gallons of varnishes, and 721,432 gallons of cellulose lacquers. The materials used by the industry included lithopone, 15,842,379 lb.; reduced titanium pigments, 3,232,946 lb.; pure zinc oxide, 3,148,377 lb.; leaded zinc oxides, 3,987,884 lb.; asbestine or talc, 4,700,461 lb.; whiting, 14,466,131 lb.; tung oil, 4,694,099 lb.; and perilla oil, 5,648,673 lb.

THE FLATTENED CAN.—The economical production of "open-top" bodies of cans, which are used for fruits, vegetables and other foodstuffs, requires an elaborate and costly line of synchronised machines to form the blanks into cylinders, hook and lock their edges, automatically solder them, and finally to true them and flange the ends; in addition, skilled operation and maintenance are necessary. Such mass production plant is not a paying proposition for individual canneries which may operate for only a few months each summer. Hence many canners, large and small, prefer to buy their cans ready made from specialist firms who mass produce them extremely cheaply in a range of sizes. The disadvantage of this policy is the expense involved in transporting to canneries in remote districts bulky empty cans instead of compact boxes of tin-plate. An ingenious idea which overcomes this drawback is the flattened can. The can body with the side seam properly laid down and soldered, but not flanged, is flattened by gentle pressure so that the bends are radiused sufficiently to avoid a sharp crease. These can bodies are packed separately from the lids and bottoms which are supplied stamped to shape and lined with sealing compound ready for use. In order to make cans from the flattened bodies the canner requires three simply operated machines which restore them to cylindrical shape, flange them, and attach the bottoms. The cost of the re-forming machinery is considerably less than £100 sterling, and is quickly recovered in the savings made in freightage.

"TRAINING ARMY CRAFTSMEN."—In the paragraph which we published in our issue of May 9th, under the heading "Training Army Craftsmen," it was stated that men who pass the complete course are classified as Class II tradesmen on return to their units and are employed at their trade. We are informed that there was a slip in the official announcement, which should have read Class III instead of Class II.

LABOUR AND THE BUILDING TRADE.—In the course of a broadcast address delivered on Tuesday evening, June 3rd, Mr. George Hicks, the Parliamentary Secretary to the Ministry of Works and Buildings, outlined coming changes in the building industry. He said that one which would be shortly introduced would be the application of a modified form of the Essential Work Order, which would mean that building men must stay building men. The industry, he claimed, had been greatly weakened since the war began by the claims of the fighting services, and by the usual wastage. The industry could not afford to lose a single hour of building labour from now onward. While the new conditions were a wartime measure, every sympathy was felt for the men in the industry, and every effort was being made on their behalf. Mr. Hicks also said there might be an early call for volunteers for a large mobile corps of building workers, which could be moved about the country as required. Part of the work of this corps would be the repair of houses.

Personal and Business

VISCOUNT COWDRAY and Mr. R. V. Perfect have been appointed to the board of directors of Saunders-Roe, Ltd.

MR. J. P. TIVEY, of the Australian General Electric Pty., Ltd., has been nominated as President-elect of the Institution of Engineers of Australia for 1941.

SIR GEOFFREY R. CLARKE, managing director of the Telegraph Construction and Maintenance Company, Ltd., has been re-elected President of the London Chamber of Commerce.

COMMANDER SIR CHARLES CRAVEN, R.N. (ret.), chairman and managing director of Vickers-Armstrongs, Ltd., has been appointed President of the British Employers' Confederation.

W. T. HENLEY'S TELEGRAPH WORKS COMPANY, Ltd., informs us that its store and office staff at 11, Holborn Viaduct has been removed to Demby House, Carlton Avenue East, Wembley, Middlesex.

MR. W. H. REDFERN has retired from the chairmanship of Redfern's Rubber Works, Ltd., Hyde, Cheshire. The board has elected Mr. J. Arthur Redfern as chairman and Mr. T. H. Redfern as deputy chairman.

THE London and North-Eastern Railway announces that Mr. H. S. Davies, district engineer, Leeds, has been appointed district engineer, King's Cross. Mr. A. K. Terris has been appointed acting district engineer at Leeds.

WE note with regret the death, on May 20th, of Mr. John Trifitt, who was formerly assistant engineer for new works, North-Eastern Area, London and North-Eastern Railway. He was seventy-eight years of age and retired in 1928.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Chemical Engineering Group

Tuesday, June 10th.—Chemical Society's Rooms, Burlington House, Piccadilly, W.1. "The Human Factor in Chemical Engineering Processes," G. H. Miles. 2.30 p.m.

Fuel Luncheon Club

Thursday, June 12th.—Connaught Rooms, Great Queen Street, Kingsway, W.C.2. Luncheon. "Oil and the War," A. E. Dunstan. 12.40 for 1.10 p.m.

Incorporated Municipal Electrical Association

Thursday, June 12th.—Clifton Picture House, Clifton, York. General meeting. 11 a.m.

Institution of Electrical Engineers

To-day, June 6th.—METER AND INSTRUMENT SECTION: Waldorf Hotel, Aldwych, W.C.2. Informal luncheon. 12.40 for 1 p.m.

Thursday, June 12th.—S. MIDLAND STUDENTS: Watt Memorial Institute, Great Charles Street, Birmingham. "Engineering Electronics," E. May and Flight-Lieut. Newnham. 7 p.m.

Newcomen Society

Friday, June 13th.—Summer excursion. Assemble Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1. 9.50 a.m.